Engineering 333
Fall 2006
Calvin College

Wind Energy Design Project

Professor Matthew Kuperus Heun

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1. Management

1.1 INTRODUCTION

The objective of this project was to demonstrate Calvin's interest in alternative energy. The development of a short-term plan to implement a demonstration wind turbine and a long-term plan to determine the feasibility of a larger turbine for the future demonstrates this interest.

The class was divided into five teams: management, external relations, long-term technology, short-term technology, and campus infrastructure. While each team had its own objectives, everyone worked together to share information and accomplish the overall project goals. This management technique provided necessary structure and simulated an environment typically found in a career environment.

1.2 BACKGROUND

Every year, the ENGR 333 class takes on a semester long project that challenges the students to examine a current thermodynamic design opportunity on campus. This year the focus was on utilizing the wind resources available at Calvin College. A grant was received from the Energy Office of the State of Michigan for $5,000 to erect a small demonstration turbine ranging from 1 to 3 kW. Upon receiving the grant, Calvin College gave an additional $6,000 to provide a total project budget of $11,000. The Wind Energy Interest Group will be handling the construction and implementation of the proposed system.

1.3 SIGNIFICANT IMPACT

One requirement of the project was to make a significant impact on the college. However, the definition of this impact was needed to provide define the scope of the project. Separate definitions of significant impact were selected due to the individual nature of the two sections. The significant impact for the short-term project focused on providing educational opportunities for the college and community. These include class projects for the students and the creation of a template for residential turbine implementation. The short-term project will also demonstrate the feasibility of wind power in West Michigan. The long-term definition was focused on the economic viability of wind power over the lifespan of the turbine. The large scale turbine will also provide further educational opportunities for the college and surrounding community.

1.4 RESULTS

The final recommendation for the small scale wind turbine is the use of the Skystream 3.7 from Southwest Windpower. This turbine produces a rated output of 1.8 kW with a maximum output of 2.4 kW. It has a cut-in speed of 8 mph which is lower than most wind turbines in this category. The Skystream also has a unique built-in inverter which reduces the cost. The recommended location of the turbine is on the edge of the nature preserve near the Gainey Althetic Fields. This site is on Calvin's campus and is protected by the fence around the nature preserve. This is an open area away from tall obstructions where future campus developments are unlikely. The recommended tower is a 35 ft. monopole. This option has the smallest footprint and meets the aesthetic requirements of the college. The amount of power output and wind speed will be displayed in the Bunker Center kiosk, an interactive display informing visitors how green energy is being utilized on campus. The explanation of these decisions can be found in the appendices.

The recommendation for the large scale project includes two different wind turbines. The first option is the Enercon E33 producing 330 kW of power. This smaller and less expensive option will reduce the amount of power purchased from an external source. The second option is the Enercon E55 producing 800 kW of power. This option has a greater initial capital cost, however it would provide greater economic payback than the E33. Unfortunately this option is less likely to be implemented due to the potential conflicts with neighbors because of its size. The recommended site for the large scale turbine is near the site of the demonstration turbine. The explanation of these decisions can be found in the appendices. With either turbine option, Calvin College will make a statement about its position on renewable energy and its desire to care for God's world.

1.5 CONCLUSION

Wind energy is an innovative and expanding industry that has a promising future in power generation for the world. This project has provided the students in ENGR 333 with an excellent opportunity to examine the possibilities of wind power. These results will be passed on to the Wind Energy Interest Group to assist them in the construction and implementation of a demonstration wind turbine on campus. Additionally, the results from the large scale research could provide an excellent basis for future considerations of renewable energy usage at Calvin College.

2. EXTERNAL RELATIONS

2.1 INTRODUCTION

The responsibilities of the external relations team include researching zoning regulations and developing a communications strategy for interacting with campus politics, neighbors, utility companies, etc. The recommended short term site is the Gainey Field site, which is located within the City of Kentwood. Because of this, we contacted the Kentwood Zoning Administrator regarding zoning regulations and found we are required to apply for a non-use variance. In addition to that application, we must apply to tie into the Consumer's Energy electrical grid. We recommend tying into the grid at the building at the Gainey Fields, which requires contact with the Grand Rapids Christian High School because they are renting the land from Calvin College. Finally, we provided information about the project to various Calvin College departments.

2.2 SITE SELECTION

Our team recommends the site located to the north-west of the Gainey Fields on East Paris Avenue, just inside the fence of the Calvin College Nature Preserve. The criteria used for this site selection was mainly the distance from surrounding neighbors and the existing fence that will provide security to the turbine. The distance from the surrounding neighbors affects the approval of the non-use variance application. The neighbors within 300 feet of the Calvin College land border in the City of Kentwood will be contacted and invited to the zoning meeting. The existing fence by the site is important to protect both the community and the equipment.

In order to obtain a visual conception of the projected height of the turbine, we conducted an experiment. The experiment consisted of tying colorful balloons to a sixty (60) foot string and taking pictures from various locations in the area. Photo results are shown in Appendix B.1.

2.3 ZONING REQUIREMENTS

The short term Gainey Field site is currently zoned as R1-C Single Family Residential, which restricts the height of accessory buildings to fifteen (15) feet. In order to change this restriction, we must apply for a non-use variance. This form and instructions for application are attached as Appendix B.2. Terry Schweitzer, Kentwood Community Development Director Zoning Administrator, provided us with this information.

An option for the long term site is the Coopersville Landfill in Polkton Charter Township. This site is currently zoned as Agriculture, which limits the height to thirty-five (35). To change this requirement, a special use application must be filed. We have not acquired a form for this process. Sean Myers from Polkton Charter Township provided us with this information.

2.4 UTILITY REQUIREMENTS

Consumer's Energy allows connection to the grid if certain requirements are met. These requirements are outlined in Appendix B.3 along with the necessary applications. Part of the application requires past electricity use of the building at Gainey Fields. Grand Rapids Christian High has supplied a spreadsheet of the energy usage according to the existing meter (Appendix B.3.1). If the application is accepted, Consumer's offers a one-to-one credit as long as the credits are used up by June of each year.

2.5 ENVIRONMENTAL EFFECTS

The main environmental concern that relates to a wind turbine has been the number of birds that die due to the rotating blades. However this number is insignificant compared to bird deaths caused by other man-made structures. According to Wikipedia, "in the United States, turbines kill 70,000 birds per year, compared to 57,000,000 killed by cars and 97,500,000 killed by collisions with plate glass." The NWCC reports that: "Based on current estimates, windplant related avian collision fatalities probably represent from 0.01% to 0.02% (i.e., 1 out of every 5,000 to 10,000) of the annual avian collision fatalities in the United States."

2.6 CONTACT LIST

In order to facilitate communication with external sources, we maintained a contact list. To reduce the number of exchanges between the external source and differing team members, the list shows the original team member who contacted the source, and it was requested that the same team member contacts the source throughout the project. The list is shown in Appendix B.4.

2.7 INFORMATIONAL BROCHURE

To easily provide information regarding this project, we are in the process of creating an informational brochure. We recommend providing copies of the brochure to the Kentwood Zoning Administrator for use during the zoning meetings.

2.8 COSTS

The costs related to the external relations portion of the project are shown in Table 1.

Table 1: External Relations Related Costs

	Cost
	$
Non-Use Variance Application	100
Net Metering Application	100
Informational Brochure	$.50/copy
Total Cost	**~$200**

3. SHORT-TERM TECHNOLOGY

3.1 INTRODUCTION

The short term technology plan for wind energy on Calvin's campus includes a recommendation for a 1-3 kW wind turbine to be integrated with the Bunker Interpretive Center contributing to the building's emphasis on renewable energy. This turbine will serve as an educational demonstration for students and the surrounding community. This recommendation includes proposals for the following aspects of the design:

- Turbine Model
- Tower (and support system)
- Site Location
- Installation Method (Hardware and Electrical)

These proposals show comparisons between alternative options and identify the associated costs.

3.2 ANALYSIS

3.2.1 TURBINE

In addition to the power requirement, the cost of the selected wind turbine had to provide sufficient funds to cover the tower price, the hardware installation price, and the electrical installation prices. Since the purpose of the turbine is primarily educational, the power performance became a secondary consideration. Indicators of the power performance include the rated power output, the rated wind speed, and the cut-in wind speed (wind speed at which the turbine begins turning). Other important considerations in the turbine include the history of the product's operation, and visual and audible aesthetics.

3.2.2 TOWER

The tower selection decision process considered many variables and options to meet the goals and requirements of the project. The price of the overall wind turbine project was subject to a budget, the tower is a significant portion of the turbine cost so it is important to choose a tower which fits within these constraints. The height of the turbine in comparison to the height of objects in its surroundings is critical in that the higher the turbine is placed, the more power-producing wind it will be capable of receiving. Two main types of towers considered are lattice and mono pole; both provide aesthetic and functionality strengths and weaknesses which were considered in tower selection. Environmental impact was considered including concerns such as ground footprint, noise pollution, and wildlife considerations.

3.2.3 SITE

We chose the site of the wind turbine based on safety, grid connection, wind availability and public visibility. Grid connection is critical allowing the power generated by the turbine to be easily and cost-effectively tied into a source for usage. Wind availability is directly correlated to site obstructions, meaning we additionally chose the sight based on the surroundings. Finally, our team considered the public in our site selection in that we wanted it to be safely placed behind a fence and far enough from neighbors to avoid a potential view obstruction or noise pollution issue.

3.2.4 INSTALLATION

Installation will be primarily conducted by Calvin College physical plant staff. Installation includes soil testing, concrete pouring, hub attachment, tower erection and grid connection. Southwest pole and installation kit parts will be used to maintain the factory warranty.

3.3 RESULTS

Our final recommendation for the short-term technology is the Southwest Skystream 3.7 turbine on a 35’ monopole located in the Nature Preserve near Gainey Field. We also have a contingency plan if the Skystream does not work out; the Bergey XL1 turbine on a 35’ monopole in the Nature Preserve near Gainey Field. A cost analysis for both of these turbines and different tower types is shown in Figure 1.

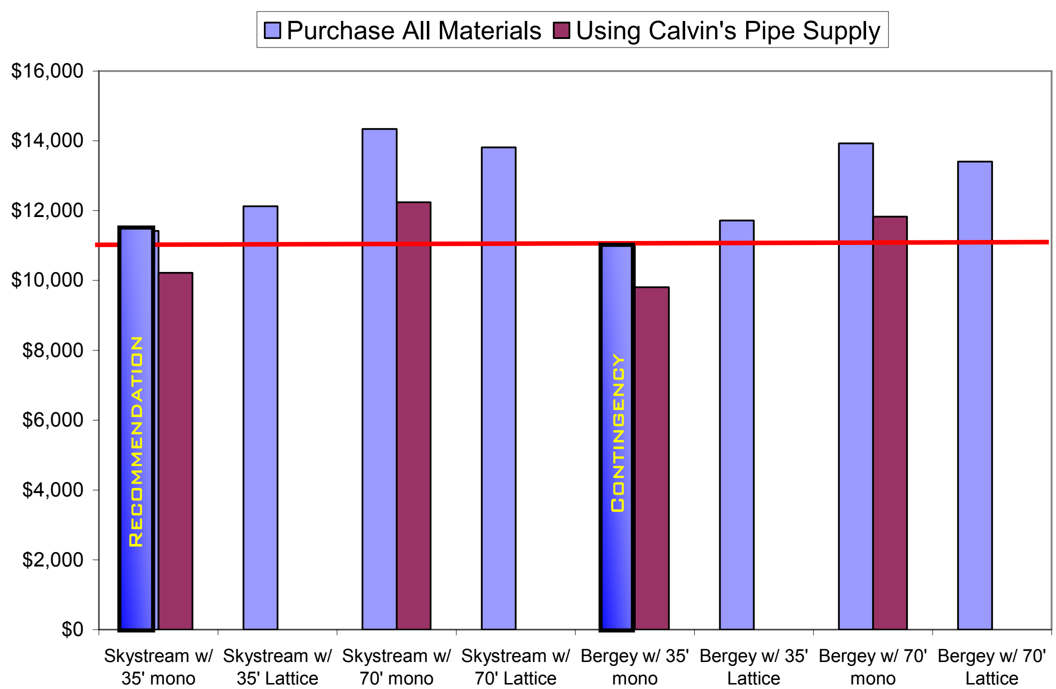

Figure 1: Net Cost Summary for Skystream and Bergey XL1

3.4 CONCLUSION

As shown in Figure 1, both recommendations are slightly over budget. It would be possible to reduce cost by using Calvin’s pipe for the tower, but this would result in forfeiting the warranty on the turbines. Therefore, because the recommendation is only about $500 over budget, we believe that it is worth the extra money to purchase the pipe to keep the warranty, and that the educational benefits of the Skystream outweigh the costs.

4. LONG-TERM TECHNOLOGY

4.1 INTRODUCTION

The purpose of the long term analysis is to determine the hardware, siting, and integration plan for anything beyond the short term demonstration turbine. Cost models for various design options have also been determined.

4.2 ANALYSIS

4.2.1 LOCATION

The long term team decided early on that location was a key factor to this project. The major decision quickly became if the turbine would be on campus or off campus. On campus provides several advantages such as direct power into Calvin's grid without going through the power company and easy access for maintenance and educational ventures. Off campus would be a better option from a public opinion standpoint, because in designing the turbine there may be less weight on local opinion. See Appendix 3.1 for further comments on location selection.

4.2.2 TURBINE SELECTION

Significant impact has been defined as producing a significant amount of power, showing economic feasibility, and providing educational opportunities. Any turbine producing over 100kW requires a hub height above 40m, and wind speed increases as height increases. This is in direct conflict with FAA regulations and public opinion. Turbines are also chosen based on availability. In general some manufacturers do not supply in small quantities. Reasoning for manufacturer choice is found in Appendix 3.3.

4.2.3 WIND SPEED DATA

Wind speed is a critical piece of information when choosing a wind turbine because it is the main variable in determining power output. It is important to have wind data from the turbine hub height or if that is not possible measurements from multiple heights to facilitate the extrapolation of the data. In depth wind data is necessary to accurately compute total power output from the turbine. Rough data can be found from Michigan Wind Energy Resource Maps, which were created in conjunction with the National Renewable Energy Laboratory. These maps provide a range of wind speeds at a certain height. Wind shear can be estimated from the maps. Before any construction starts a full year of wind data taken at the estimated hub height should be obtained to ensure feasibility. Appendix 3.2 describes how wind speed data was found and used in more detail.

4.2.4 FINANCIAL

The financial analysis was mainly done with pre-existing spreadsheets that forecast financial status for a 25 year life. Many assumptions had to be made in order to complete this analysis, and several sensitivity studies were done regarding certain key variables. An overall trend was found that turbine size was proportional to net present value. Major assumptions and financial models can be seen in depth in Appendix 3.5.

4.3 RESULTS & CONCLUSIONS

The location chosen for the long term turbine is on campus to the north of the Gainy sports fields. On campus was chosen mainly because of the cost of land that would be needed if the turbine were off campus, and because having the turbine on campus provides easy access for educational uses.

The manufacturer chosen for Calvin College's wind turbine is Enercon. Enercon was chosen because of its willingness to work with groups that are interested in small scale wind production verses entire wind farms. Because of the large increase in demand over recent years some manufacturers will only work with groups that are interested in producing massive wind farms. Enercon was also chosen because of the gearless design it incorporates. A large part of the maintenance of wind turbines comes after a five or ten year period of operation when the gearbox needs to be replaced. With Enercon this maintenance cost is much lower because there is no gearbox to be replaced after an extended period of time.

Two turbines from Enercon were chosen for the final recommendation. This allows for changes in the financial and physical environment which may affect the outcome of our models. The smaller model is the E33. The E33 is rated at 330kW and has a rotor diameter of 33.4m. The hub height for the E33 is 50m and the cut-in (minimum running) speed is 3m/s. The larger model is the E53. The E53 is rated at 800kW and has a rotor diameter of 52.9m. The hub height for the E53 is 73m and the cut-in speed is 2m/s.

Wind speeds were taken from Michigan Wind Energy Resource Maps, which were created in conjunction with the National Renewable Energy Laboratory. The velocity at the 50 meter hub height for our first option, the Enercon E33 is 5.8 m/s. The velocity at the 73 meter hub height for the second option, the Enercon E53 is 6.4 m/s. These speeds have variance of plus or minus .5 m/s. The wind shear is calculated as .28 but could range from 0.22 to 0.37. This uncertainty can have dramatic effects on power production and emphasizes the need for on-site wind data acquisition.

From a financial perspective it was found that the turbine size was proportional to return over 25 years. The E33 had a net present value of -$7,760 and a 4.9% rate of return. It would have a breakeven point of approximately 15.6 years and would produce 670 MWh/yr. In addition it would offset an estimated 565 tonnes ofCO_2 each year. The E53 has a net present value of $738,125 and a 8.7% rate of return. The positive cash flow point is 10.9 years and approximately 2053 MWh are produced each year. The E53 would also offset 1,732 tonnes of CO_2 each year.

The long term team found that the base case cost models are very sensitive to several uncertain variables. This stresses the need to acquire more information so that an accurate business model can be created. Of particular importance are the sensitivity of the power produced in relation to changes in wind speed. Sensitivity studies are contained in Appendix 3.5.

<u>5. INFRASTRUCTURE</u>

5.1 INTRODUCTION

It was the infrastructure group's responsibility to take the power generated from a turbine and use it to make a 'significant impact' on the college campus. This is accomplished by connecting the turbine into a power grid and displaying its generation capacity at the Bunker Interpretive Center. The infrastructure group has two main projects; connecting the short and long term turbines. The short term project consisted of two main decisions: where and how to connect to the grid, and how to gather information from the turbine. For the long term project, the infrastructure group needed to determine the components needed to connect a large scale inverted power generator in a manner which adheres to Consumers Energy standards.

5.2 ANALYSIS

5.2.1 SHORT TERM

5.2.1.1 Power Connection

Connecting the turbine to the grid was the first infrastructure priority. Since the Skystream turbine includes an inverter, this task involved running appropriately sized cable from the turbine to the nearest grid connection location. The NEC standard for acceptable voltage drop is 2%, so the chosen cable could not exceed this at the rated turbine load of 1800 W over the specified cable distance of 460 feet.

Cable sizes and costs for both copper and aluminum conductor were calculated and compared. The copper conductor (7 AWG) cost $1,190 while the aluminum conductor (5 AWG) cost only $339. With this significant cost difference in mind, we chose an aluminum conductor to attach the turbine to the utility shed grid connection point. The cost and power analysis of this system is outlined in Table 2.

Table 2: Short Term Transmission Specifications

Turbine Power		1800	W
Line Voltage		240	V
Wire Type		Aluminum	
Transmission Length		400	ft
Tower Height		60	ft
Power Lost		26.59	W
Voltage Drop		4.42	V
Voltage Drop		1.84%	
Efficiency		98.5%	
Wire Type	5 AWG Aluminum		
Trench Cost	$	2,550	
Wire Cost	$	339	2 conductors
CE Cost	$	500	
Total Cost	**$**	**3,389**	

5.2.1.2 Communication Devices

Our initial plan for communications involved running cables through the existing communications conduit from the Gainey Field to the Bunker Center. This plan, however, is not feasible since the communications conduit is collapsed in several places. Our final communications plan, therefore, involves purchasing the SkyStream wireless communication device for $300 and attaching it to the Ethernet connection in the nearby utility shed. At 425 feet away, this building falls well within the 1000 foot range of the communication device. The use of this device also removes any warranty complications which might arise from our tampering with the inverter to obtain a data signal.

5.2.2 LONG TERM

If a long term wind turbine is to be connected to the Calvin's grid, it ought to be placed near a primary power transmission line. Calvin would most likely need to run their primary line encased in concrete from the Prince Conference Center to the site of the turbine in order to connect to the grid. The proposed turbines have inverters built into them, which can produce a standard output of 480 V AC. This voltage will need to be stepped up with a transformer to the primary voltage of 12,000 V AC. In the case that the primary grid loses power, switchgear will need to prevent power from entering the grid. The switchgear will be located between the inverter and the connection to the primary line. If Calvin would decide to construct a full scale turbine, the project must be overseen by an approved electrician and kept in accordance with Consumer's Energy safety regulations. The estimated cost of the long term grid connection is included in the total estimated cost given in the Long Term analysis.

5.3 CONCLUSION

The wind energy problem was split into two parts for the infrastructure team. The first part is the short term turbine. The turbine has a built in inverter capable of generating 240 V AC power. Our recommendation is to transmit the power from the turbine to the nearby shed using a 5 AWG Aluminum wire. Information from the turbine will be transmitted wirelessly from the inverter to a remote receiver located in the shed. The information will be then sent through Calvin's Ethernet and displayed on the kiosk in the Bunker Center. If Calvin's primary grid is ever extended out to the Gainey Field, the turbine can then be connected directly to Calvin's grid and the power fed directly into campus. The total cost of this plan is $3,689.

The second part of the project is the long term turbine. Both turbines that are currently being considered have built in inverters that produce 480 V AC power. We have obtained diagrams from Consumer's Energy that outline the components needed to connect an inverted power generator to a primary grid. Exact components will have to be specified once the turbine is chosen. It is our recommendation that Calvin extends their primary loop if they plan to build a large scale turbine on Gainey Field.

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APPENDIX A.1 ENERGY USAGE STUDY

Initially it was determined that the significant impact of the project be defined by the amount of power used by the college. In order to understand electricity usage on campus, the electricity bills from Consumer's Energy were obtained from Dan Slager, the energy management technician at Calvin College. Four years of data were compiled and the results of this electrical usage study can be seen in the following figures.

There has been a slight increase in electrical usage over the last four years, and one of the objectives of this project was to investigate one possibility of putting a cap on the amount of electricity purchased from Consumer's Energy. This is illustrated in Figure A-1. The data from the electric bills was also used to show the cost of each month's usage as seen in Figure A-2. It is also evident from this graph that the college's montly cost of electricity has increased significantly. Finally, the cost per kWh was determined and over the last year this cost has increased dramatically as illustrated in Figure A-3.

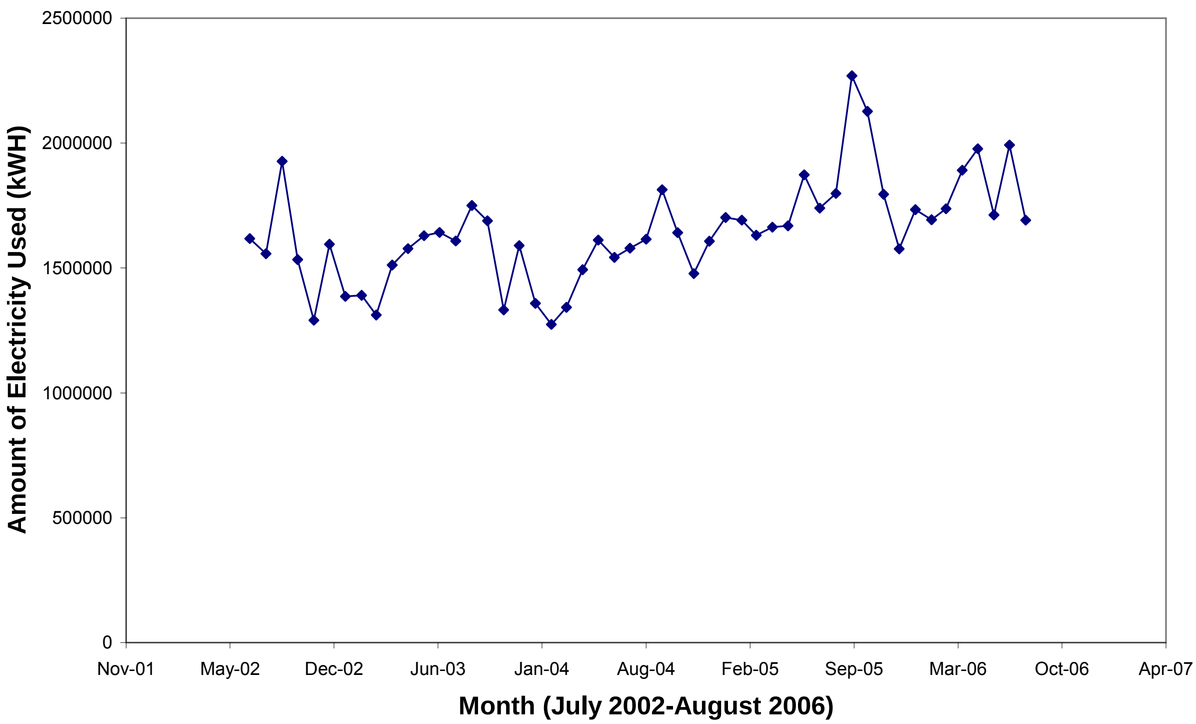


Figure A-1: Calvin Electrical Usage

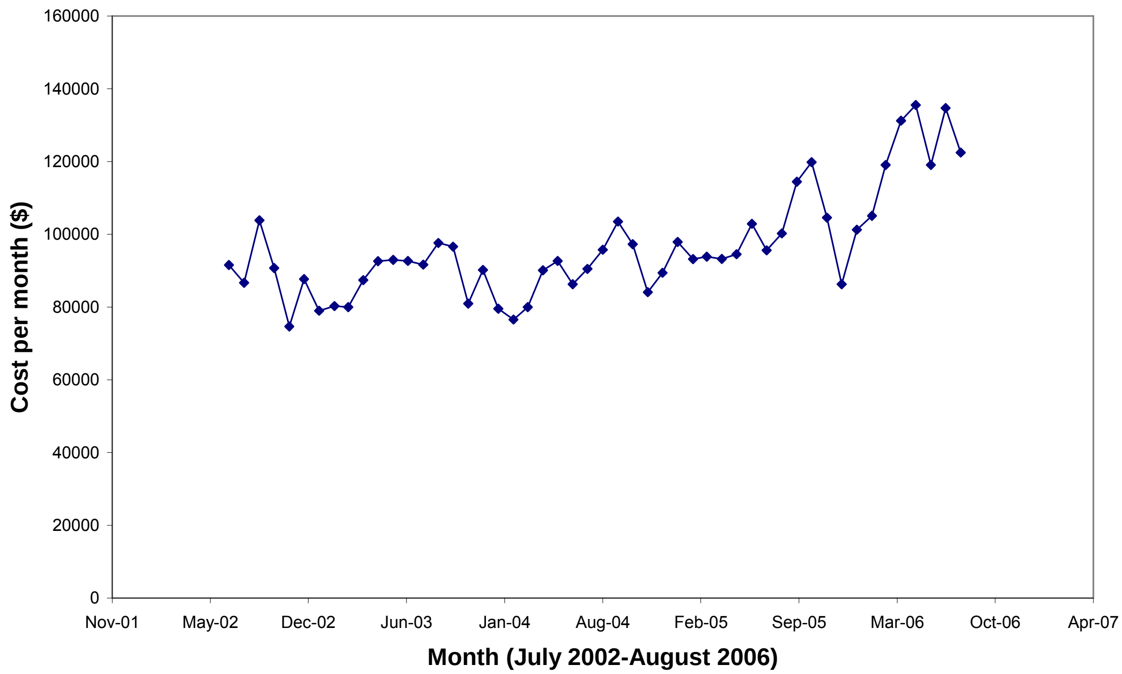


Figure A-2: Cost of Total Electrical Usage per Month

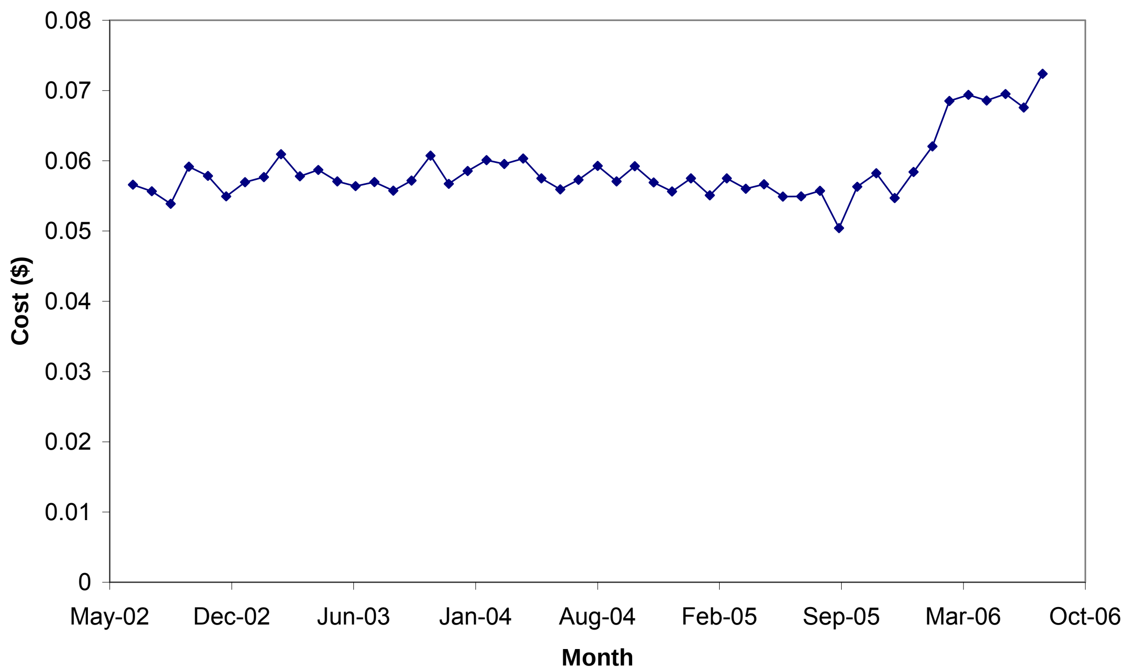
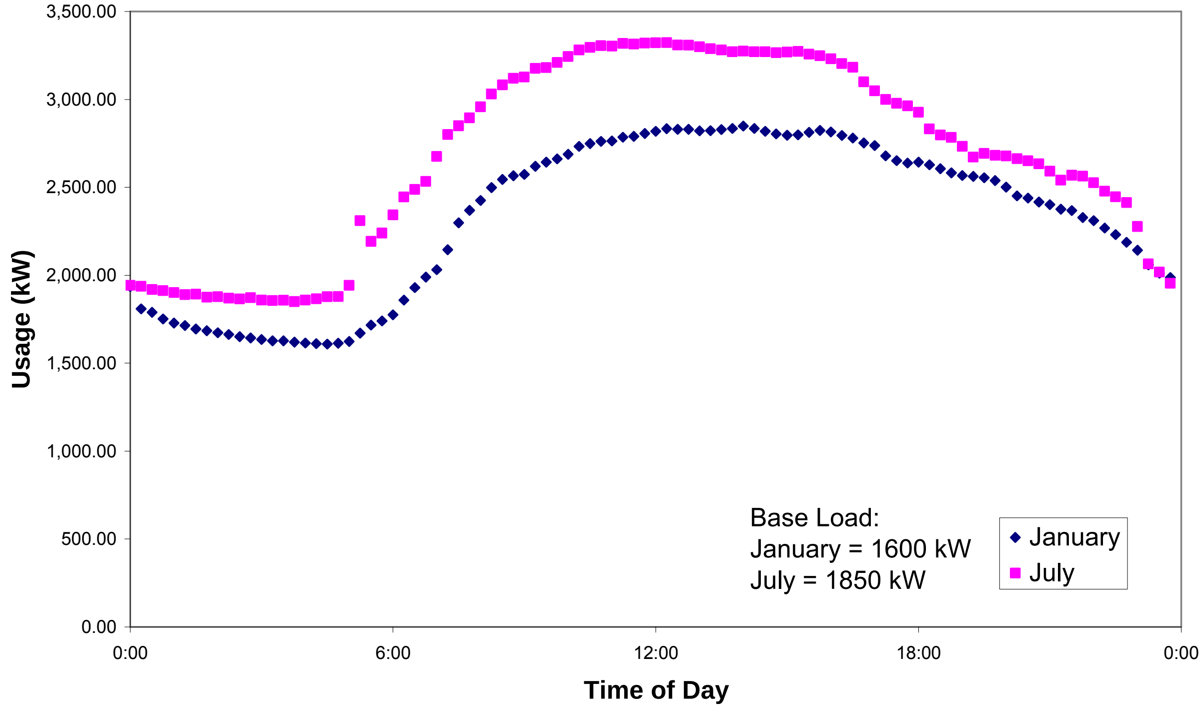


Figure A-3: Calvin College's Monthly Cost per kWh

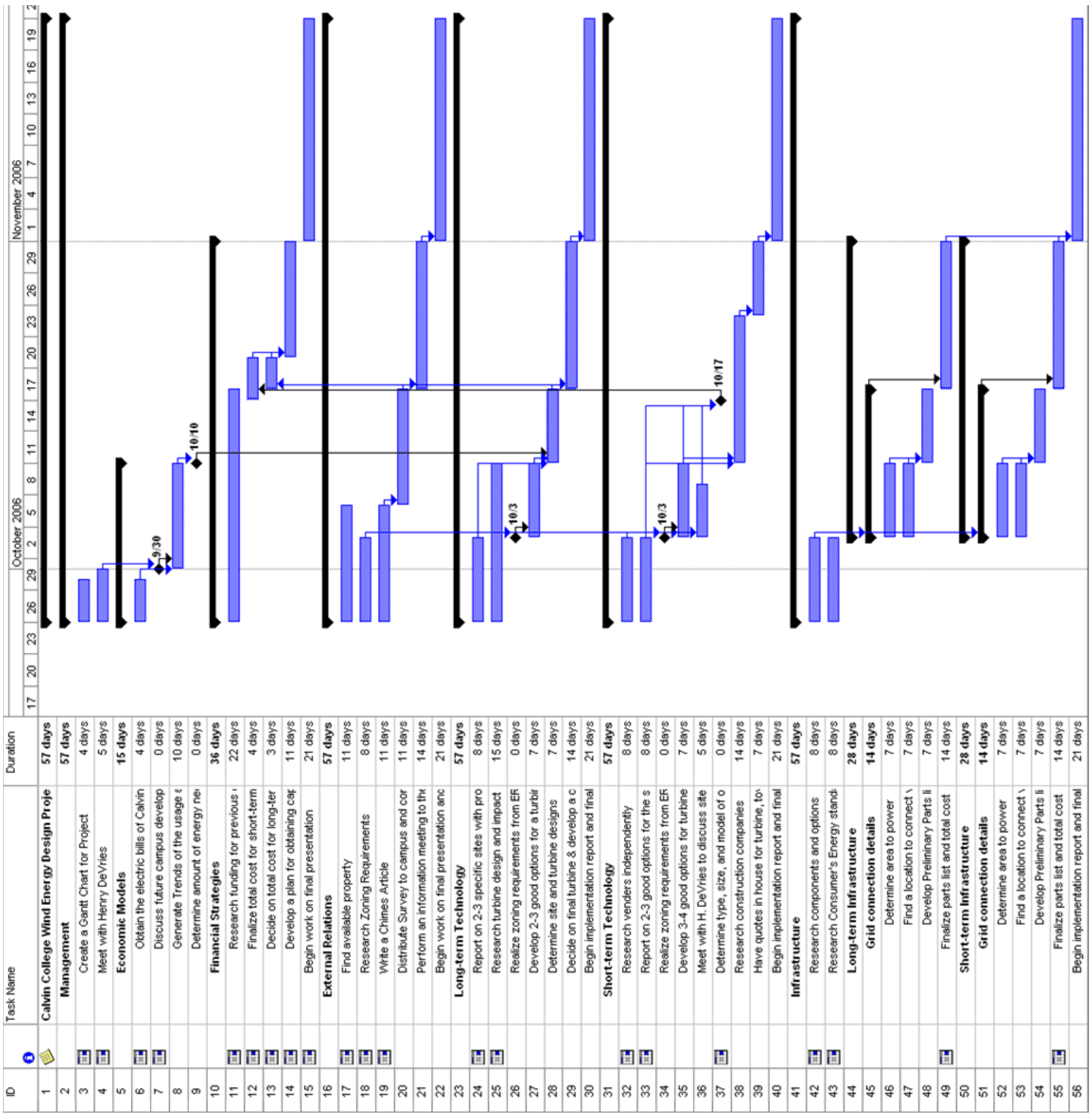
Another element of the usage study was to determine the grid loading throughout a typical day. Figure A-4 compares this data for a typical January and July.



This study in electrical usage was not used in the final determination of significant impact. However, it is interesting to see how much electricity is used on campus and the amount of money being spent by the college on electricity every year.

APPENDIX A.2 PROJECT SCHEDULING

Part of the management team's responsibility also included maintaining a schedule for the project to ensure that the required tasks were completed in a timely manner. A Gantt chart was developed to allow teams to check on their progress in comparison to the rest of the groups.



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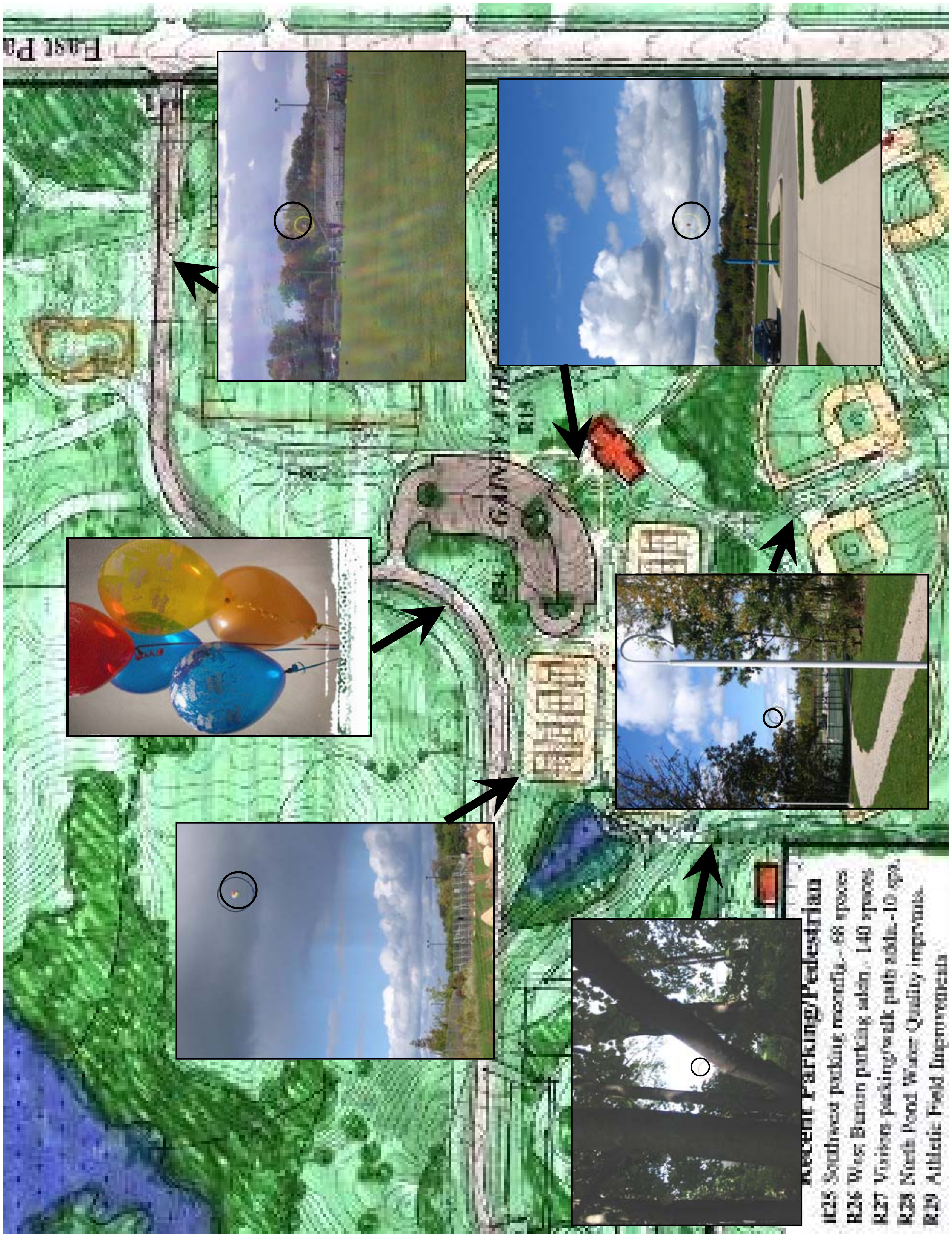
APPENDIX B.1 BALLOON EXPERIMENT



APPENDIX B.2 NON-USE VARIANCE APPLICATION

CITY OF KENTWOOD
ZONING BOARD OF APPEALS
NON-USE VARIANCE APPLICATION

APPEAL # ________________
HEARING DATE ________________

APPLICANT: Calvin College PHONE # 616-526-6148
ADDRESS: 1661 East Paris
PROPERTY OWNER: Calvin College PHONE #616-526-6148
ADDRESS: 3201 Burton St SE
LOCATION OF VARIANCE (If applicable) 41-81-02-401-005
ZONING DISTRICT OF PROPERTY: R1-C Single Family Residential
ZONING ORDINANCE SECTION (S) APPEALED: Section 3.15B
NATURE OF APPEAL: The Zoning Ordinance (requires/allows/does not permit)
Section 3.15 B states that the height restrictions of a detached accessory building shall not exceed fifteen (15) feet in height. The proposed wind turbine that Calvin College intends to construct will not exceed sixty (60) feet in height.

JUSTIFICATION OF APPEAL: Briefly describe how your appeal meets the Standards of Section 21.04B of the Kentwood Zoning Ordinance. Each standard must be met.
STANDARD (1):
The proposed property is an ideal location for a wind turbine of this scale because it is behind an existing fence, which will ensure the safety of the people who use the surrounding fields. It is also ideal because the elevation in that location will provide sufficient wind speeds to allow the turbine to function efficiently. The area chosen is not densely forested and will not require the removal of a significant amount of vegetation. This location also provides close proximity to the electrical network to which this turbine would be interconnected.

STANDARD (2):
The addition of this wind turbine is an exceptional circumstance, a one-time request for educational purposes. The wind turbine is an educational project in renewable energy that will be funded with a government grant that has already been secured. This area will not need to be rezoned because the plan is to only add this one turbine.

STANDARD (3):
This wind turbine is intended to serve as a learning tool to students at Calvin College and interested community members. It is not intended to be a source of income for the college.

STANDARD (4):
The surrounding area of this location is mostly wooded or athletic fields. The nearest house is over 300 yards away to the south and behind a dense tree line. Any residents to the north of the location would not be able to see the turbine due to the forest between the desired location and the houses. There are a number of athletic fields to the east and further east is the road, East

Paris. Calvin College owns the property to the west. The wind turbine is significantly smaller than the commercial turbines used in wind farms. This turbine should not be visible for long distances because of the tall trees that surround the area.

STANDARD (5):
This variance is a single request and will not be a repetitive event.

STANDARD (6):
The difficulty of the variance request comes from the location choice. The site was chosen due to the wind speeds that the location would supply, the available fence that would provide safety, and the closeness of the location to the electrical grid that the turbine would connect to. The difficulty is the height restriction that the area is zoned under, and it was not created by Calvin College.

I hereby certify that all of the above statements and any attachments are correct and true to the best of my knowledge.

Authorization for city staff and board members to enter the property for evaluation.

Yes ____________ No ____________

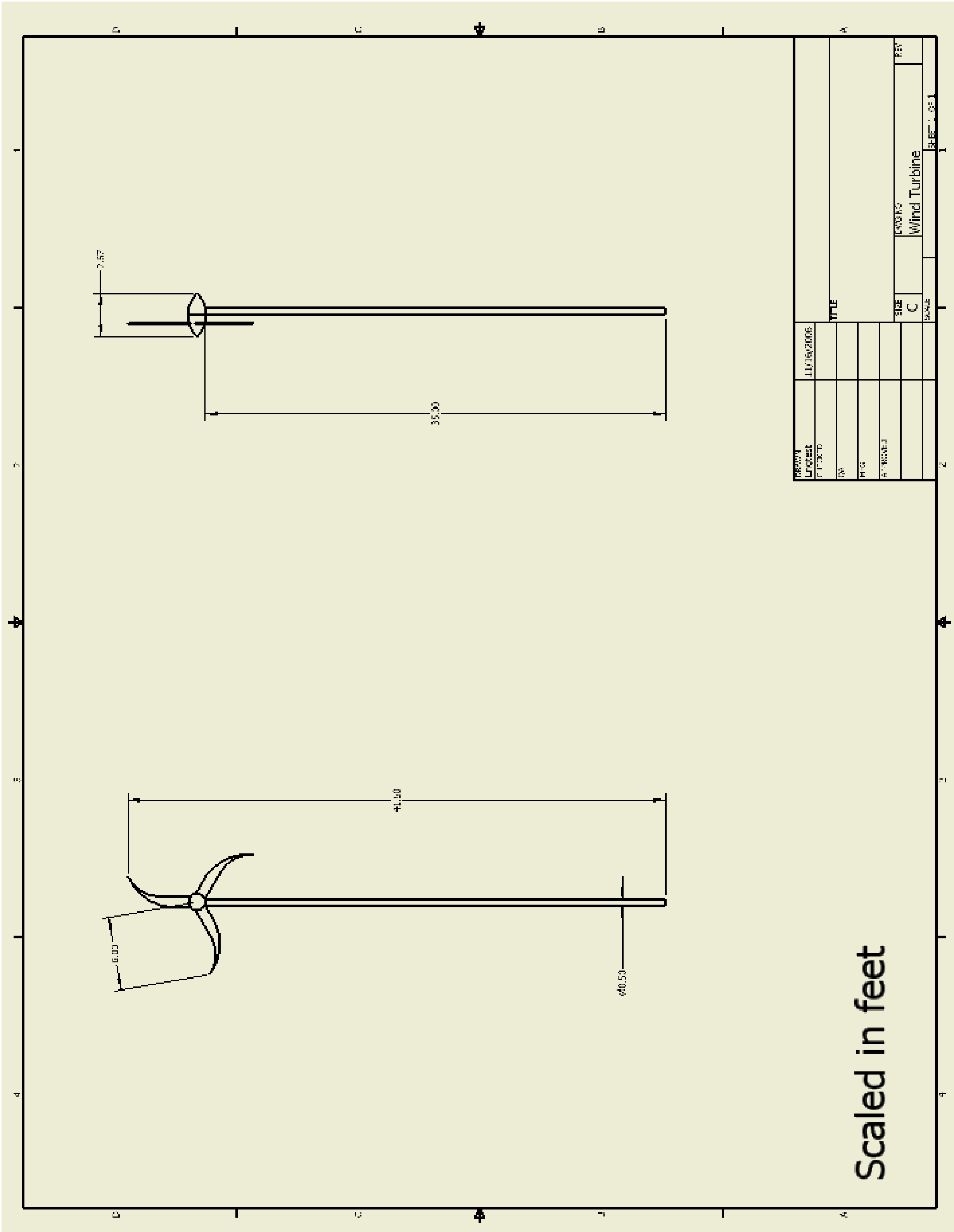
NAME OF APPLICANT: Calvin College
(Please print)

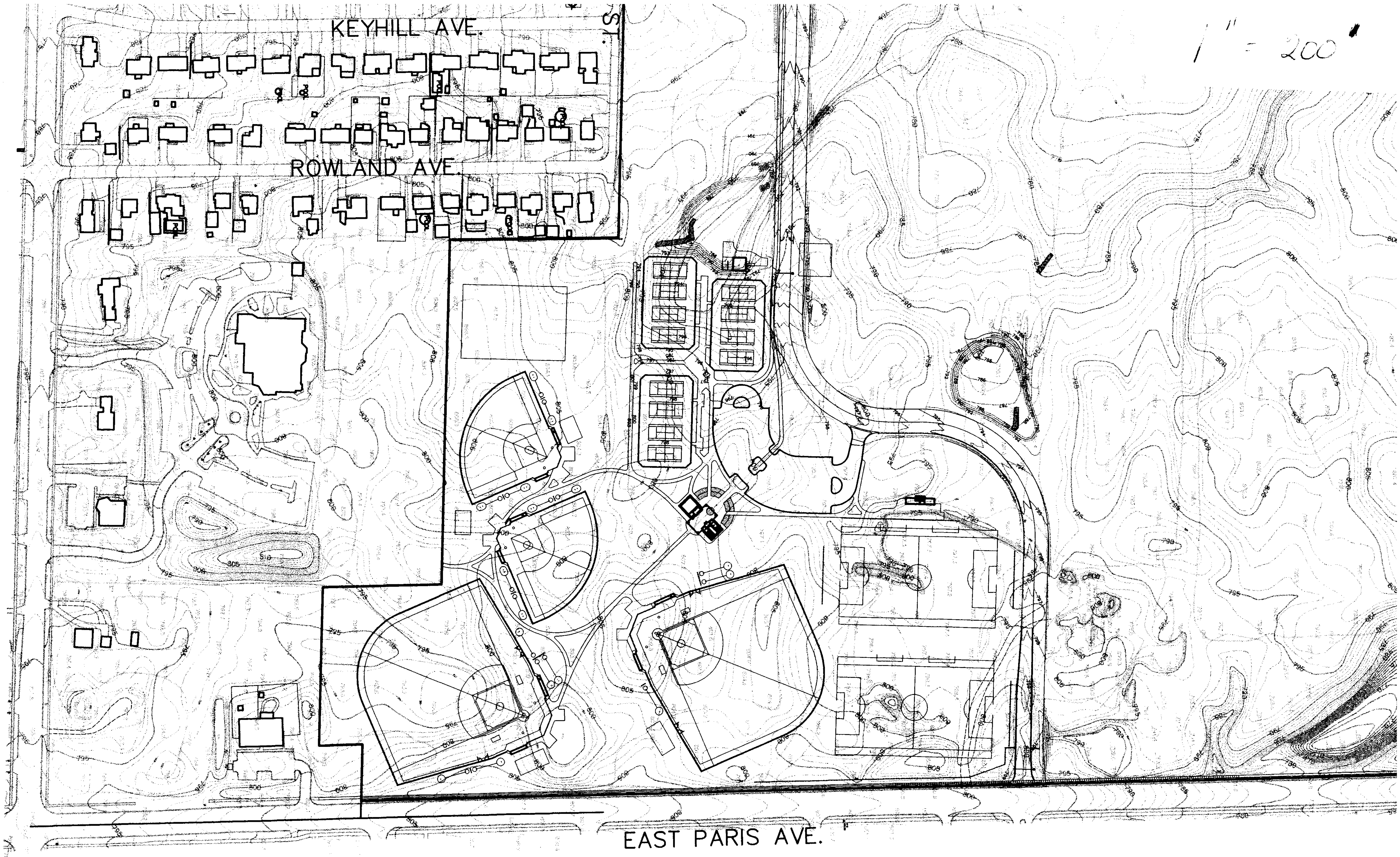
SIGNATURE OF APPLICANT: ____ DATE: __________

NAME OF PROPERTY OWNER: ____
(Please print)

SIGNATURE OF PROPERTY OWNER: __________________________________ DATE: __________

Return to Planning Department
PHONE: 554-0707, FAX NO. 698-7118


Scaled in feet
Wind Turbine
35.00
41.50


KEYHILL AVE.
ROWLAND AVE.
ST.
EAST PARIS AVE.
1" = 200'

APPENDIX B.3 CONSUMER'S APPLICATIONS

APPENDIX B.3.1 GAINEY FIELD UTILITY BUILDING ELECTRICITY USAGE

SCHOOL GAINEY ATHLETIC FIELD

METER # 98672783

ACCOUNT #

ELECTRICITY - KWH

SCHOOL YEAR 2004-2005 2005-2006

MONTH	UNITS KWH	TOTAL YTD	EST/ ACT		UNITS KWH	TOTAL YTD	EST/ ACT		CHANGE % MONTH	CHANGE % YEAR		TEMP CHANGE
SEPT	3458	3458	E		3763	3763	A		8.82%	8.82%		
OCT	2177	5635	E		2363	6126	A		8.54%	8.71%		
NOV	2087	7722	E		1872	7998	E		-10.30%	3.57%		
DEC	2460	10182	E		765	8763	Adj		-68.90%	-13.94%		
JAN	636	10818	E		815	9578	Adj		28.14%	-11.46%		
FEB	636	11454	E		716	10294	Adj		12.58%	-10.13%		
MAR	636	12090	E		497	10791	A		-21.86%	-10.74%		
APR	636	12726	E		1494	12285	E		134.91%	-3.47%		
MAY	3242	15968	E		3274	15559	A		0.99%	-2.56%		
JUN	3242	19210	ADJ		4360	19919	A		34.48%	3.69%		
JUL	4233	23443	A		3887	23806	A		-8.17%	1.55%		
AUG	3921	27364	A		3756	27562	A		-4.21%	0.72%		

Cost/Month

MONTH	Dollars	TOTAL YTD	EST/ ACT		Dollars	TOTAL YTD	EST/ ACT		CHANGE % MONTH	CHANGE % YEAR		TEMP CHANGE
SEPT	$346.36	$346.36	E		$369.91	$369.91	A		6.80%	6.80%		
OCT	$220.66	$567.02	E		$231.96	$601.87	A		5.12%	6.15%		
NOV	$211.82	$778.84	E		$194.06	$795.93	E		-8.38%	2.19%		
DEC	$248.43	$1,027.27	E		$84.15	$880.08	Adj		-66.13%	-14.33%		
JAN	$63.06	$1,090.33	E		$89.65	$969.73	Adj		42.17%	-11.06%		
FEB	$63.06	$1,153.39	E		$78.76	$1,048.49	Adj		24.90%	-9.09%		
MAR	$63.06	$1,216.45	E		$97.26	$1,145.75	A		54.23%	-5.81%		
APR	$63.06	$1,279.51	E		$154.26	$1,300.01	E		144.62%	1.60%		
MAY	$326.33	$1,605.84	E		$453.35	$1,753.36	A		38.92%	9.19%		
JUN	$325.12	$1,930.96	ADJ		$504.37	$2,257.73	A		55.13%	16.92%		
JUL	$414.81	$2,345.77	A		$474.92	$2,732.65	A		14.49%	16.49%		
AUG	$383.50	$2,729.27	A		$434.96	$3,167.61	A		13.42%	16.06%		

SCHOOL GAINEY ATHLETIC FIELD

METER # 98672783

ACCOUNT #

ELECTRICITY - KWH

SCHOOL YEAR 2004-2005

Cost/KWH

MONTH	Dollars	TOTAL YTD	EST/ ACT		Dollars	TOTAL YTD	EST/ ACT		CHANGE % MONTH	CHANGE % YEAR		TEMP CHANGE
SEPT	$0.1002	$0.1002	E		$0.0983	$0.0983	A		-1.86%	-1.86%		
OCT	$0.1014	$0.1006	E		$0.0982	$0.0982	A		-3.15%	-2.36%		
NOV	$0.1015	$0.1009	E		$0.1037	$0.0995	E		2.14%	-1.33%		
DEC	$0.1010	$0.1009	E		$0.1100	$0.1004	Adj		8.92%	-0.46%		
JAN	$0.0992	$0.1008	E		$0.1100	$0.1012	Adj		10.94%	0.45%		
FEB	$0.0992	$0.1007	E		$0.1100	$0.1019	Adj		10.94%	1.15%		
MAR	$0.0992	$0.1006	E		$0.1957	$0.1062	A		97.37%	5.53%		
APR	$0.0992	$0.1005	E		$0.1033	$0.1058	E		4.14%	5.25%		
MAY	$0.1007	$0.1006	E		$0.1385	$0.1127	A		37.57%	12.06%		
JUN	$0.1003	$0.1005	ADJ		$0.1157	$0.1133	A		15.35%	12.76%		
JUL	$0.0980	$0.1001	A		$0.1222	$0.1148	A		24.68%	14.72%		
AUG	$0.0978	$0.0997	A		$0.1158	$0.1149	A		18.40%	15.23%		

APPENDIX B.3.2 INTERCONNECTION & NET METERING APPLICATION

Contact:
Mark DeLange

If you have any questions, Mark is the only person you need to talk to.

- Need to apply for a net metering program for generating less than 30 kW.
- $100 filing fee
- $500 to buy and install two meters
    - Bidirectional meter used to measure coming and going of power on the grid
    - Regular meter to record the power generation of the turbine.
- Need to complete interconnection study.
- Mostly shows Consumers that the generator will flip off under the right conditions, and the power generation will not cause problems to the grid.
- The generator needs to be 100% compatible with the grid power (i.e. same phase, magnitude, and frequency)
- If Consumer's wants to verify our system, they may charge us for the visit.
- The credit for the excess electricity produced will be reset every year in June
- Can't make money from Consumers, only offset power consumption of Gainey Field.
- Credit transfer is considered 1 to 1, excluding filing fee and set up costs

Do not expect power production to greatly offset the cost of turbine, power production for short-term project will not be profitable

Consumers Energy

A CMS Energy Company

The Business Center
Tel: 1 800 805 0490 (toll free)
Fax: 1 877 232 4745
E-Mail: businesscenter@cmsenergy.com

October 13, 2006

Eric Malinowski
9301 Conservation St
Ada MI 49301

Dear Mr. Malinowski,

In response to your request, I am enclosing a copy of the Michigan Electric Utility Generator Interconnection Requirements for projects with aggregate generator output under 30kw, and a Net Metering Application.

Please fill out both the Interconnection Application and the Net Metering Application and return to our attention using the envelope provided, along with the $100 filing fee. This application will be used to initiate a study of your interconnection request by our Electric Systems Operations Department, which is a prerequisite for participating in the program. They will determine what, if any, facility modifications are needed to accommodate your interconnection request. For most small renewable generating systems, there are typically no modifications of facility costs outside of the required metering for the program.

Please feel free to contact me with questions.

Mark DeLange
Customer Account Manager
(616) 530-4472

(Continued From Sheet No. B-70.00)

B19. RENEWABLE RESOURCES PROGRAM (RRP) (Contd)

J. Company Termination of the RRP

Company termination of the RRP may occur under the following cases:

(1) Renewable Energy Resources are unavailable or cannot be procured to serve the program,

(2) The expenses of the RRP exceed the revenues collected from the RRP Fund or any other RRP pre-established revenue sources,

(3) Federal and/or State laws are established that may make the RRP unnecessary, noncompliant, or in need of revision,

(4) There is insufficient interest and/or participation by customers as compared to the time and costs involved in offering the RRP, and/or

(5) Other reasons not contemplated, are discussed with the MPSC and agreed upon as sufficient to terminate the RRP.

B20. NET METERING PROGRAM

A. The Net Metering Program is offered as authorized by the Michigan Public Service Commission (MPSC) in MPSC Case No. U-14346.

B. Net Metering Definition

"Net Metering" is an accounting mechanism whereby certain eligible Company customers who generate a portion or all of their own retail electricity needs are billed for generation by the Company only for their net energy consumption during each billing period.

Net energy consumption during each billing period is the amount of energy delivered by the Company to the customer, minus the amount of energy generated by the customer and delivered to the Company.

C. Net Metering Program Availability

The Net Metering Program is voluntary and is available on a first come, first served basis until the nameplate capacity of all participating generators is equal to the maximum program limit of 0.1% of the Company's peak demand for Full-Service customers during the previous calendar year. The enrollment period for the Net Metering Program shall be for a period of five years from the effective date of this tariff. During the five-year enrollment period, customers may participate for any period of time up to ten years, starting from the customer's effective service date under the program. A Net Metering Program year begins on July 1 and ends on June 30.

(Continued on Sheet No. B-72.00)

(Continued From Sheet No. B-71.00)

B20. NET METERING PROGRAM (Contd)

D. Customer Eligibility

In order to be eligible to participate in the Net Metering Program, customers must (1) generate a portion or all of their own retail electricity requirements using a renewable energy source, specifically solar, wind, geothermal, biomass, landfill gas, or hydroelectric, as set forth in Public Act 141 and (2) be Full Service customers. Biomass systems are allowed to blend up to 25% fossil fuel as needed to ensure safe, environmentally sound operation of the renewable energy system. A customer using biomass blended with fossil fuel as their renewable energy source must submit proof to the Company substantiating the percentage of the fossil fuel blend either by (1) separately metering the fossil fuel, or (2) providing other documentation that will allow the Company to correctly apply a generation credit to the output associated with the customer's renewable fuel only.

A customer's eligibility to participate in the Net Metering Program is conditioned on the full satisfaction of any payment term or condition imposed on the customer by pre-existing contracts or tariffs with the Company.

E. Customer Billing

Net Metering Program customers shall be billed and pay for their total metered usage using the same method ordinarily applied to a customer on the applicable rate schedule, absent Net Metering. The Net Metering Program customer shall receive a generation credit in the applicable billing period for the output of their generator up to their total metered usage, using *only* the *Energy Charge portion of the Power Supply Charges* per kilowatt-hour, including *the* associated Power Supply Cost Recovery *Factor charge,* as set forth on the customer's applicable rate schedule. For a biomass system blending fossil fuel, the generation credit shall apply only to the output associated with the renewable fuel and exclude the output from the fossil fuel. The customer's generator output in excess of the total metered usage, if any, shall be carried over to the next month's billing period (see Section K., Net Excess Generation Credits).

Net Metering Program customers taking service on an energy only rate, specifically Rate A-1, A-3, A-4, A-5, B, B-1, GH, H, J-1, L-1, L-2, L-3, L-4, PS-1, PS-2 or R-1 will receive a credit in the applicable billing period for the distribution *of* all self-generated kWh consumed on the customer's premises, using *only* the Distribution Charge *portion of the Delivery Charges* per kilowatt-hour as set forth on the customer's applicable rate schedule.

No refunds shall be made for any customer contribution required under Paragraphs H, I or J of this tariff or for any other costs incurred by the customer in connection with participation in the Net Metering Program.

F. Application for Service

In order to participate in the Net Metering Program, a customer shall submit a completed Net Metering Program Application to the Company. Net Metering Program Applications shall be available through direct mail or through the Company's website.

(Continued on Sheet No. B-73.00)

(Continued From Sheet No. B-72.00)

B20. NET METERING PROGRAM (Contd)

G. Generator Requirements

The generation equipment must be located on the customer's premises, serving only the customer's premises and must be intended primarily to offset a portion or all of the customer's requirements for electricity. The customer need not be the owner or operator of the eligible generation equipment. For dispatchable generators, the nameplate rating of the generator(s) shall not exceed 30 kW in aggregate and shall not be sized to exceed the customer's capacity needs for any single billing address. For non-dispatchable generators, the nameplate rating of the generator(s) shall not exceed 30 kW in aggregate and shall not exceed the customer's annual energy needs, measured in kWh. The customer is required to provide the Company with a capacity rating in kW of the generating unit and a projected monthly and annual kilowatt-hour output of the generating unit when completing the Company's Net Metering Application.

H. Generator Interconnection Requirements

The requirements for interconnecting a generator with the Company's facilities are contained in the Michigan Public Service Commission's Electric Interconnection Standards Rules (R 460.481-460.489), the Michigan Electric Utility Generator Interconnection Requirements and the Company's Generator Interconnection Supplement to Michigan Electric Utility Generator Interconnection Requirements. All such interconnection requirements must be met prior to the effective date of a customer's participation in the Net Metering Program. The customer must sign an Interconnection & Operating Agreement with the Company and fulfill all requirements as specified in the Agreement.

I. Metering Requirements

Net Metering customers are required to have metering equipment capable of measuring the energy that is consumed by the customer separately from the energy generated by the customer's generator.

Metering requirements include an electronic bi-directional billing meter and a separate generation meter (including associated equipment) all of which must meet the Company's standard specifications and requirements. Metering equipment shall be specified, furnished, installed, read, maintained and owned by the Company.

Any and all costs associated with metering that are incurred to participate in the Net Metering Program are the responsibility of the customer. The customer has the option to either (1) pay for costs associated with metering in full prior to taking service under the Net Metering Program or (2) pay for costs associated with metering over a 12-month period in equal monthly payments.

J. Distribution Line Extension and/or Extraordinary Facilities

The Company reserves the right to make special contractual arrangements with Net Metering Program customers whose utility service requires investment in electric facilities, as authorized by the Company's Extraordinary Facilities, General Provisions of Service, and Distribution Systems, Line Extensions and Service Connections provisions as set out in the Company's Schedule of Rates Governing the Sale of Electric Service. The Company further reserves the right to condition a customer's participation in the Net Metering Program on a satisfactory completion of any such contractual requirements.

(Continued on Sheet No. B-74.00)

(Continued From Sheet No. B-73.00)

B20. NET METERING PROGRAM (Contd)

K. Net Excess Generation Credits

Net Excess Generation (NEG) is the amount of electricity generated by the customer using an eligible renewable energy fuel, in excess of the customer's own metered usage in any billing month, which is delivered to the Company. One NEG Credit is equal to the *Energy Charge portion of the Power Supply Charges,* including associated Power Supply Cost Recovery charges, of one kilowatt-hour of electricity as stated on the customer's applicable rate schedule. NEG credits will be applied only to the generation portion of the customer's monthly total metered consumption.

NEG Credits, if any, will be carried over from month to month, limited to a 12-month billing cycle. Following the customer's June billing cycle, the customer's NEG Credit balance will be reset to zero. Any unused NEG Credits remaining in the customer's account following the customer's June billing cycle will be retained by the Company. The value of the unused NEG Credits retained by the Company will be used to offset costs associated with the Net Metering Program.

NEG Credits are nontransferable. In the event that a customer terminates participation in the Net Metering Program, existing NEG Credits will be applied to the generation portion of the customer's final bill as a Net Metering Program participant. NEG Credits remaining on the customer's account after the final bill, if any, will be forfeited by the customer and will be used by the Company to offset Net Metering Program costs.

L. Customer Termination from the Net Metering Program

A participating customer may terminate participation in the Company's Net Metering Program at any time for any reason on sixty days' notice. In the event the Net Metering customer terminates participation prior to the Company's recovery of costs associated with any Net Metering service provided to the customer, the customer shall pay the Company for all such costs.

M. Company Termination of Net Metering Interconnection or Net Metering Program

Company termination of the Net Metering interconnection shall occur if the customer's facilities are determined not to be in compliance with technical, engineering, or operational requirements suitable for the Company's distribution system.

Company termination of the Net Metering Program may occur upon receipt of MPSC approval.

(Continued on Sheet No. B-75.00)

(Continued From Sheet No. B-74.00)

B20. NET METERING PROGRAM (Contd)

N. Company Cost Recovery of Net Metering Program Costs

The Company shall recover all costs associated with the interconnection of the customer's generator with the Company's electric system as approved by Public Act 141 and the Michigan Public Service Commission's Electric Interconnection Standards Rules and Requirements.

The Company shall be authorized to recover eligible costs associated with the Net Metering Program, including program operating costs, transmission and distribution (T&D) costs attributable to the Net Metering customers, and the above-market costs, if any, of generation credits provided to Net Metering customers. The Company reserves the right to recover all eligible program costs in a future proceeding(s) when actual cost data from the Net Metering Program is available.

Net Metering Program analysis will occur at the end of the second Net Metering Program year and at the end of the fourth Net Metering Program year at a minimum. Additional analyses will be done by the Company when necessary.

O. Net Metering Program Status and Evaluation Reports

(1) The Company will submit an annual status report to the MPSC Staff by September 30 of each year including Net Metering Program data for the previous 12 months, ending June 30. The Company's status report shall maintain customer confidentiality (unless the customer's consent has been obtained) and shall include, at a minimum, the following information:

(a) Total number of participating customers,
(b) Five-digit zip code for each participating customer,
(c) Starting month and year for each participating customer,
(d) Technology type and size in kW for each participating customer,
(e) Total Net Excess Generation by technology type, and
(f) Any additional information the Company believes is necessary in order to properly monitor and evaluate its Net Metering Program.

(2) The Net Metering Program will be monitored and evaluated through the Michigan Renewable Energy Program process. After the fourth year of the program, the MREP Collaborative will present to the MPSC a Michigan Net Metering Evaluation Report, including recommendations about the continuation and any proposed alterations of the program. The Company may, at its discretion, petition the MPSC for an extension of its program. The Net Metering Program shall terminate after five years unless extended by the MPSC.

CONSUMERS ENERGY

NET METERING PROGRAM APPLICATION

Return completed form to: Consumers Energy - Net Metering Program, One Energy Plaza, EP12-433, Jackson, MI 49201

I wish to participate in Consumers Energy's Net Metering Program for the following account:

Account Number: ______________________

Account Name: ______________________

Service Address: ______________________

City/State/Zip: ______________________

Customer Name: ______________________

Daytime Telephone: ______________________

Alternate Telephone: ______________________

E-mail Address: ______________________

Customer Type: ☐ Residential Customer
☐ Non-Residential Customer

Please provide the following generator information:

Capacity Rating of the Generator(s) in kW: ______________________

Projected Monthly kWh Output of the Generator: ______________________

Projected Annual kWh Output of the Generator: ______________________

Renewable Energy Source: ______________________

Please specify one of the following: solar, wind, geothermal, biomass, landfill gas, hydroelectric, or other

Please provide estimated date for generator installation/operation:

Has Interconnection Agreement been completed? ☐ YES ☐ NO

Net Metering Program Applicants must complete and sign an Interconnection & Operating Agreement with the Company and fulfill all requirements as specified within the agreement. All Interconnection requirements must be met prior to the effective date of a customer's participation in the Net Metering Program.

A separate meter is required for Net Metering installations which will be specified, furnished, installed, read, maintained, and owned by Consumers Energy. All costs associated with metering that are incurred to participate in the Net Metering Program are the responsibility of the participating Net Metering customer. Approved Net Metering participants may elect to pay for the additional meter in 12 equal installments on their electric bill. Please indicate your payment preference below. Please note that costs for the Interconnection and Interconnection Study must be paid in advance (see Interconnection & Operating Requirements and Agreement.)

☐ Upon approval of this Net Metering application, I elect to pay for the new meter in 12 equal installments on my monthly electric billing.

☐ If Net Metering application is approved, I elect to pay for the meter upfront along with costs for Interconnection and Interconnection Study.

Customer Signature ______________________ Date ______________

Print Name ______________________

MICHIGAN ELECTRIC UTILITY

Generator Interconnection Requirements

Projects with
Aggregate Generator Output
Under 30 kW

INTRODUCTION

This Generator Interconnection Requirements document outlines the process, requirements, and agreements used to install or modify generation projects with aggregate generator output capacity ratings less than 30 kW and designed to operate in parallel with the Utility electric system. Technical requirements (data, equipment, relaying, telemetry, metering) are defined according to type of generation, location of the interconnection, and mode of operation (Flow-back or Non-Flow-back). The process is designed to provide an expeditious interconnection to the Utility electric system that is both safe and reliable.

This document has been filed with the Michigan Public Service Commission (MPSC) and complies with rules established for the interconnection of parallel generation to the Utility electric system in the MPSC Order in Case No. U-13745.

The term "Project" will be used throughout this document to refer to a merchant plant and other electric generating equipment and associated facilities that are not owned or operated by an electric utility. The term "Project Developer" means a person that owns, operates, or proposes to construct, own, or operate, a Project.

This document does not address other Project concerns such as environmental permitting, local ordinances, or fuel supply. Nor does it address agreements that may be required with the Utility and/or the transmission provider, or state or federal licensing, to market the Project's energy. An interconnection request does not constitute a request for transmission service.

It may be possible for the Utility to adjust requirements stated herein on a case-by-case basis. The review necessary to support such adjustments, however, may be extensive and interfere with study fees and the project schedule established by the MPSC and addressed in these requirements. Therefore, if requested by the Project Developer, adjustments to these requirements will only be considered if the Project Developer agrees in advance to compensate the Utility for the added costs of the necessary additional reviews and to also allow the Utility additional time for the additional reviews.

The Utility may apply for waiver from one or more provisions of these rules and the MPSC may grant a waiver upon a showing of good cause.

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INTERCONNECTION PROCESS

The Interconnection Process

This section outlines the process for interconnecting Projects with aggregate output less than 30 kW to the Utility electric system. This includes both new Projects and modifications to existing Projects. The general process is shown in Figure 1.

The Utility is required to complete all of its obligations for interconnection of the Project to the Utility system within 2 weeks from the time a complete Interconnection Application is received by the Utility.

A completed Interconnection Application consists of an application, data (Appendix B or C), and filing fee.

Delays that are the responsibility of the Project Developer or attributable to the time lapse while the Utility diligently seeks to secure necessary rights-of-way, governmental permitting, zoning requirements, etc, will not be counted in the time to meet the 2 week deadline. The Utility shall have no responsibility to pursue court action to obtain these items.

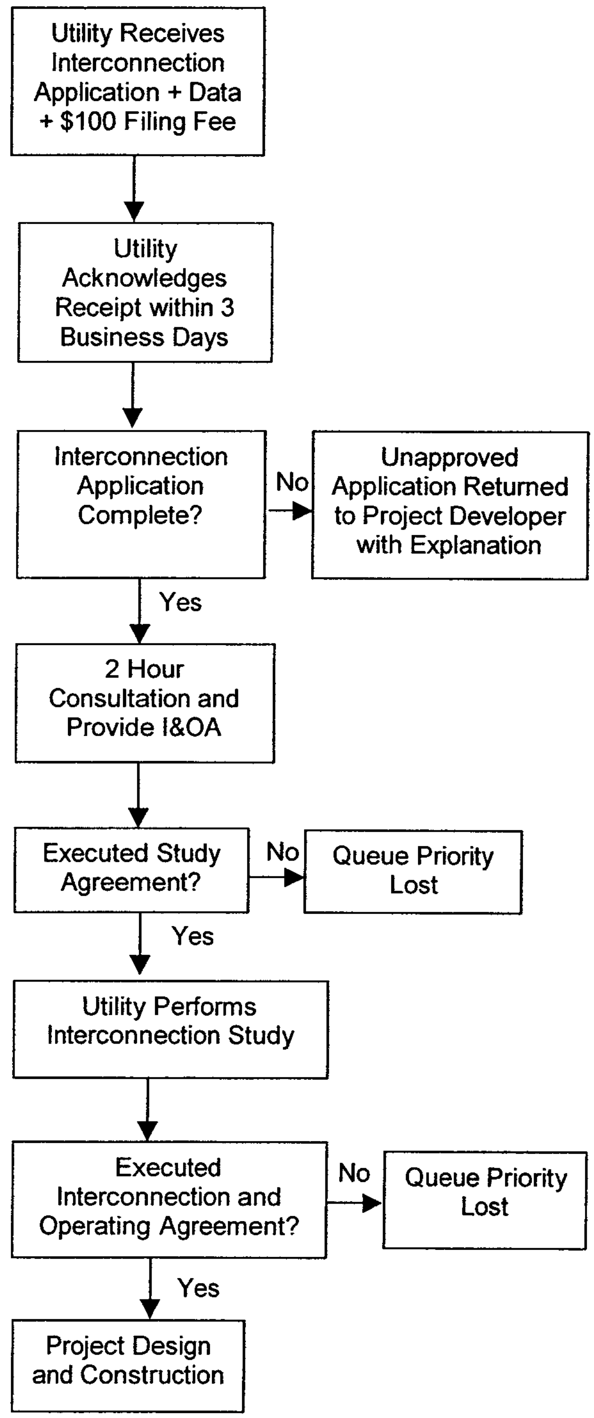
Interconnection Application

The Project Developer must first submit an Interconnection Application to the Utility. A separate application is required for each Project or Project site. A blank Interconnection Application can be found in Appendix A. A list of the required interconnection data, depending on the capacity rating and type of generation, can be found in Appendices B and C.

A complete submittal of required interconnection data and filing fee of $100 must accompany the Interconnection Application. The Utility will notify the Project Developer within 3 business days of receipt of an Interconnection Application. If any portion of the Interconnection Application, data submittal, or filing fee is incomplete and/or missing, the unapproved Interconnection Application will be sent back to the Project Developer with the deficiencies clearly identified.

Once the Utility has accepted an Interconnection Application, the Project is assigned a position in the Project queue maintained by the Utility. The Project position in the Project queue is determined by the date the Utility received the accepted Interconnection Application. The Utility will provide the Project Developer up to two hours of consultation related to the Project's interconnection to the Utility system and will include a good faith estimate of the Utility's charges to complete the

Figure 1: The Interconnection Process



interconnection, including the estimated study fees, based on the information available to the Utility at that time.

Interconnection Study

The Utility will perform an Interconnection Study to determine the impact of the Project on the Utility's system, and the Utility system modifications required for safe and reliable interconnection of the Project to the Utility's system. The Project Developer is required to sign the Interconnection Study Agreement found in Appendix D and is encouraged to return the signed Interconnection Study Agreement to the Utility with the completed Interconnection Application to avoid delays in the interconnection process. Any delay in execution of the Interconnection Study Agreement will not toll the interconnection deadlines.

The Utility will charge the Project Developer for the costs associated with completion of the Interconnection Study. The costs will not exceed the lesser of either of the following:

(1) Five percent of the estimated total cost of the Project, or

(2) $10,000

Interconnection Study fees are not required if the Interconnection Study determines that the Project's aggregate export capacity is less than 15% of the line section peak load and the project does not contribute more than 25% of the maximum short circuit current at the Point of Common Coupling (PCC) as defined by IEEE 1547.

It is typical for Projects less than 30 kW to be less than 15% of the line section peak load and less than 25% of the maximum short circuit current at the PCC.

Interconnection and Operating Agreement

The Utility will submit an Interconnection and Operating Agreement (I&OA) to the Project Developer, as soon as practical, after the 2 hour consultation described earlier. A sample Interconnection and Operating Agreement can be found in Appendix E.

The Interconnection and Operating Agreement will cover matters customarily addressed in such agreements in accordance with Good Utility Practice, including, without limitation, construction of facilities, system operation, interconnection cost and billing, defaults and remedies, insurance, and liability. All Utility costs associated with making modifications to its distribution system will be paid by the Project Developer.

Any delay in execution of the Interconnection and Operating Agreement will not count toward the interconnection deadlines.

Project Design and Construction

After the Interconnection and Operating Agreement is executed, the Utility will proceed to acquire necessary rights-of-way, procure required equipment, and design and construct the Interconnection Facilities.

Ongoing Operations

The Project Developer and Utility will exchange contact information and update this information from time to time. A sample Contact List can be found in Appendix F.

TECHNICAL REQUIREMENTS

Technical Requirements

The following discussion details the technical requirements for interconnection of Projects less than 30 kW. For Projects within this capacity rating range, the Utility has made a significant effort to simplify the technical requirements. This effort has resulted in adoption of IEEE Std. 1547, Standard for Interconnecting Distributed Resources with Electric Power Systems, being incorporated herein by reference.

Certain requirements, as specified by this document, must be met to provide compatibility between the Project and the Utility's electric system, and to assure that the safety and reliability of the electric system is not degraded by the interconnection.

Upgraded revenue metering may be required for the Project.

Major Component Design Requirements

The data requested in Appendix B or C, for all major equipment and relaying proposed by the Project Developer, must be submitted as part of the initial application for review and approval by the Utility. The Utility may request additional data be submitted as necessary during the study phase to clarify the operation of the Project.

Once installed, the interconnection equipment must be reviewed and approved by the Utility prior to being connected to the Utility's electric system and before Parallel Operation is allowed.

Data
The data that the Utility requires to evaluate the proposed interconnection is documented on a "fill in the blank" checklist by generator type in Appendices B and C.

A site plan, one-line diagrams, and interconnection protection system details of the Project are required as part of the application data. The generator manufacturer supplied data package should also be supplied.

Isolating Transformer(s)
If a Project Developer installs an isolating transformer, the transformer must comply with the current ANSI Standard C57.12.

The type of generation and electrical location of the interconnection will determine the isolating transformer connections. Allowable connections are detailed in the "Specific Requirements by Generator Type" section. Note: Some Utilities do not allow an isolation transformer to be connected to a grounded Utility system with an ungrounded secondary (Utility side) winding configuration, regardless of the Project type. Therefore, the Project Developer is encouraged to consult with the Utility prior to submitting an application.

Isolation Device
After review, this device may not be required by the Utility. If required and/or installed, this device would be placed at the Point of Common Coupling (PCC). It can be a circuit breaker, circuit switcher, pole top switch, load-break disconnect, etc., depending on the electrical system configuration. The following are required of the isolation device:

- Must be approved for use on the Utility system.
- Must comply with current relevant ANSI and/or IEEE Standards.
- Must have load break capability, unless used in series with a three-phase interrupting device.

TECHNICAL REQUIREMENTS

- Must be rated for the application.
- If used as part of a protective relaying scheme, it must have adequate interrupting capability. The Utility will provide maximum short circuit currents and X/R ratios available at the PCC upon request.
- Must be operable and accessible by the Utility at all times (24 hours a day, 7 days a week)
- The Utility will determine if the isolation device will be used as a protective tagging point. If the determination is so made, the device must have a visible open break, provisions for padlocking in the open position and it must be gang operated. If the device has automatic operation, the controls must be located remote from the device.

Interconnection Lines
Any new line construction to connect the Project to the Utility's electric system will be undertaken by the Utility at the Project Developer's expense.

Relaying Design Requirements

Regardless of the technology of the interconnection, for simplicity for all Projects in this capacity rating range, the interconnection relaying system must be certified by a nationally recognized testing laboratory to meet IEEE Std. 1547. The data submitted for review must include information from the manufacturer indicating such certification, and the manufacturer must placard the equipment such that a field inspection can verify the certification.

A copy of this standard may be obtained (for a fee) from the Institute of Electrical and Electronics Engineers (www.ieee.org).

Momentary Paralleling
For situations where the Project will only be operated in parallel with the Utility's electric system for a short duration (100 milliseconds or less), as in a make-before-break automatic transfer scheme, no additional relaying is required. Such momentary paralleling requires a modern integrated Automatic Transfer Switch (ATS) system, which is incapable of paralleling the Project with the Utility's electric system. The ATS must be tested, verified, and documented by the Project Developer for proper operation at least every 2 years. The Utility may be present during this testing.

Automatic Reclosing
The Utility employs automatic multiple-shot reclosing on most of the Utility's circuit breakers and circuit reclosers to increase the reliability of service to its customers. Automatic single-phase overhead reclosers are regularly installed on distribution circuits to isolate faulted segments of these circuits.

The Project Developer is advised to consider the effects of Automatic Reclosing (both single phase and three phase) to assure that the Project's internal equipment will not be damaged. In addition to the risk of damage to the Project, an out-of-phase reclosing operation may also present a hazard to Utility equipment since this equipment may not be rated or built to withstand this type of reclosing. The Utility will determine relaying and control equipment that needs to be installed to protect its own equipment from out-of-phase reclosing. Installation of this protection will be undertaken by the Utility at the Project Developer's expense.

Single-Phase Sectionalizing
The Utility also installs single-phase fuses and/or reclosers on its distribution circuits to increase the reliability of service to its customers. Three-phase generator installations may require replacement of fuses and/or single-phase reclosers with three-phase circuit breakers or circuit reclosers at the Project Developer's expense.

TECHNICAL REQUIREMENTS

Specific Requirements by Generator Type

Synchronous Projects
An isolation transformer may be required for three-phase Synchronous Generator Facilities. Except as noted below, the isolation transformer must be incapable of producing ground fault current to the Utility system; any connection except delta primary (Project side), grounded-wye secondary (Utility side) is acceptable. A grounded-wye - grounded-wye transformer connection is acceptable only if the Project's single line-to-ground fault current contribution is less than the Project's three-phase fault current contribution at the PCC. Protection must be provided for internal faults in the isolating transformer; fuses are acceptable.

For a sample One-Line Diagram of this type of facility, see Appendix B.

Induction Projects
For three-phase installations, any isolation transformer connection is acceptable except grounded-wye (Utility side), delta (Project side). Protection must be provided for internal faults in the isolating transformer; fuses are acceptable. The Utility does not require the Project Developer to provide any protection for Utility system ground faults.

For a sample One-Line Diagram of this type of facility, see Appendix B.

Inverter-Type Projects
No isolation transformer is required between the generator and the secondary distribution connection. If an isolation transformer is used for three-phase installations, any isolation transformer connection is acceptable except grounded-wye (Utility side), delta (Project side). Protection must be provided for internal faults in the isolating transformer; fuses are acceptable. The Utility does not require the Project Developer to provide any protection for Utility system ground faults.

For a sample One-Line Diagram of this type of facility, see Appendix C.

Relay Setting Criteria
The relay settings for Projects less than 30 kW must conform to the values specified in IEEE Std. 1547.

Maintenance and Testing
The Utility reserves the right to test the relaying and control equipment that involves protection of the Utility's electric system whenever the Utility determines a reasonable need for such testing exists.

The Project Developer is solely responsible for conducting and documenting proper periodic maintenance on the generating equipment and its associated control, protective equipment, interrupting devices, and main Isolation Device, per manufacturer recommendations.

Routine and maintenance checks of the relaying and control equipment must be conducted in accordance with provided written test procedures which are required by IEEE Std. 1547, and test reports of such testing shall be maintained by the Project Developer and made available for Utility inspection upon request. [NOTE – IEEE 1547 requires that testing be conducted in accordance with written test procedures, and the nationally recognized testing laboratory providing certification will require that such test procedures be available before certification of the equipment.]

Installation Approval
The Project Developer must provide the Utility with 5 business days advance written notice of when the Project will be ready for inspection, testing, and approval.

TECHNICAL REQUIREMENTS

Prior to final approval for Parallel Operation, the Utility reserves the right to inspect the Project and require action to assure conformance to the requirements stated herein.

Miscellaneous Operational Requirements

Miscellaneous requirements include synchronizing equipment for Parallel Operation, reactive requirements, and system stability limitations.

Operating in Parallel
The Project Developer will be solely responsible for the required synchronizing equipment and for properly synchronizing the Project with the Utility's electric system.

Voltage fluctuation at the PCC during synchronization is limited by IEEE Std. 1547.

These requirements are directly concerned with the actual operation of the Project with the Utility:

- The Project may not commence parallel operation until approval has been given by the Utility. The completed installation is subject to inspection by the Utility prior to approval. Preceding this inspection, all contractual agreements must be executed by the Project Developer.

- The Project must be designed to prevent the Project from energizing into a de-energized Utility line. The Project's circuit breaker or contactor must be blocked from closing in on a de-energized circuit.

- The Project shall discontinue parallel operation with a particular service and perform necessary switching when requested by the Utility for any of the following reasons:

    1. When public safety is being jeopardized.

    2. During voltage or loading problems, system emergencies, or when abnormal sectionalizing or circuit configuration occurs on the Utility system.

    3. During scheduled shutdowns of Utility equipment that are necessary to facilitate maintenance or repairs. Such scheduled shutdowns shall be coordinated with the Project.

    4. In the event there is demonstrated electrical interference (i.e. Voltage Flicker, Harmonic Distortion, etc.) to the Utility's customers, suspected to be caused by the Project, and such interference exceeds then current system standards, the Utility reserves the right, at the Utility's initial expense, to install special test equipment as may be required to perform a disturbance analysis and monitor the operation and control of the Project to evaluate the quality of power produced by the Project. In the event that no standards exist, then the applicable tariffs and rules governing electric service shall apply. If the Project is proven to be the source of the interference, and that interference exceeds the Utility's standards or generally accepted industry standards, then it shall be the responsibility of the Project Developer to eliminate the interference problem and to reimburse the Utility for the costs of the disturbance monitoring installation, removal, and analysis excluding the cost of the meters or other special test equipment.

    5. When either the Project or its associated synchronizing and protective equipment is demonstrated by the Utility to be improperly maintained, so as to present a hazard to the Utility system or its customers.

6. Whenever the Project is operating isolated with other Utility customers, for whatever reason.

7. Whenever the Utility notifies the Project Developer in writing of a claimed non-safety related violation of the Interconnection Agreement and the Project Developer fails to remedy the claimed violation within ten working days of notification, unless within that time either the Project Developer files a complaint with the MPSC seeking resolution of the dispute or the Project Developer and Utility agree in writing to a different procedure.

If the Project has shown an unsatisfactory response to requests to separate the generation from the Utility system, the Utility reserves the right to disconnect the Project from parallel operation with the Utility electric system until all operational issues are satisfactorily resolved.

Reactive Power Control
Synchronous generators that will operate in the Flow-back Mode must be dynamically capable of providing 0.90 power factor lagging (delivering reactive power to the Utility) and 0.95 power factor leading (absorbing reactive power from the Utility) at the Point of Receipt. The Point of Receipt is the location where the Utility accepts delivery of the output of the Project. The Point of Receipt can be the physical location of the billing meters or a location where the billing meters are not located, but adjusted for line and transformation losses.

Induction and Inverter-Type Projects that will operate in the Flow-back Mode must provide for their own reactive needs (steady state unity power factor at the Point of Receipt). To obtain unity power factor, the Induction or Inverter-Type Project can:

1. Install a switchable Volt-Ampere reactive (VAR) supply source to maintain unity power factor at the Point of Receipt; or

2. Provide the Utility with funds to install a VAR supply source equivalent to that required for the Project to attain unity power factor at the Point of Receipt at full output.

There are no interconnection reactive power capability requirements for Synchronous, Induction, and Inverter-Type Projects that will operate in the Non-Flow-back Mode. The Utility's existing rate schedules, incorporated herein by reference, contain power factor adjustments based on the power factor of the metered load at these facilities.

Site Limitations
The Project Developer is responsible for evaluating the consequences of unstable generator operation or voltage transients on the Project equipment and determining, designing, and applying any relaying which may be necessary to protect that equipment. This type of protection is typically applied on individual generators to protect the generator facilities.

The Utility will determine if operation of the Project will create objectionable voltage flicker and/or disturbances to other Utility customers and develop any required mitigation measures at the Project Developer's expense.

Revenue Metering Requirements

The Utility will own, operate, and maintain all required billing metering equipment at the Project Developer's expense.

Non-Flow-back Projects
A Utility meter will be installed that only records energy deliveries to the Project.

TECHNICAL REQUIREMENTS

Flow-back Projects
Special billing metering will be required. The Project Developer may be required to provide, at no cost to the Utility, a dedicated dial-up voice-grade circuit (POTS line) to allow remote access to the billing meter by the Utility. This circuit shall be terminated within ten feet of the meter involved.

The Project Developer shall provide the Utility access to the premises at all times to install, turn on, disconnect, inspect, test, read, repair, or remove the metering equipment. The Project Developer may, at its option, have representative witness this work.

The metering installations shall be constructed in accordance with the practices, which normally apply to the construction of metering installations for residential, commercial, or industrial customers. For Projects with multiple generators, metering of each generator may be required. When practical, multiple generators may be metered at a common point provided the metered quantity represents only the gross generator output.

The Utility shall supply to the Project Developer all required metering equipment and the standard detailed specifications and requirements relating to the location, construction, and access of the metering installation and will provide consultation pertaining to the meter installation as required. The Utility will endeavor to coordinate the delivery of these materials with the Project Developer's installation schedule during normal scheduled business hours.

The Project Developer may be required to provide a mounting surface for the metering equipment. The mounting surface and location must meet the Utility's specifications and requirements.

The responsibility for installation of the equipment is shared between the Utility and the Project Developer. The Project Developer may be required to install some of the metering equipment on its side of the PCC, including instrument transformers, cabinets, conduits, and mounting surfaces. The Utility shall install the meters and communication links. The Utility will endeavor to coordinate the installation of these items with the Project Developer's schedule during normal scheduled business hours.

Communication Circuits

The Project Developer is responsible for ordering and acquiring the telephone circuits required for the Project interconnection. The Project Developer will assume all installation, operating, and maintenance costs associated with the telephone circuits, including the monthly charges for the telephone lines and any rental equipment required by the local telephone provider. However, at the Utility's discretion, the Utility may select an alternative communication method, such as wireless communications. Regardless of the method, the Project Developer will be responsible for all costs associated with the material and installation, whereas the Utility will be responsible to define the specific communication requirements.

The Utility will cooperate and provide Utility information necessary for proper installation of the telephone circuits upon written request.

All telephone circuit (both voice and data) must be analog circuits.

APPENDIX A

INTERCONNECTION APPLICATION

GENERATOR INTERCONNECTION APPLICATION
AGGREGATE GENERATOR OUTPUT BELOW 30 kW

1. The undersigned Project Developer submits this Generator Interconnection Application and appropriate filing fee to interconnect a new Project to the Utility Electric System or to increase the capacity of an existing Project interconnected to the Utility Electric System.

2. A Project Developer requesting interconnection or an increase in the capacity of an existing Project to the Utility Electric System must provide the following information:

   a. Completed Interconnection Application Data sheet appropriate for the capacity rating and type of generating unit(s), as found in Utility's Generator Interconnection Requirements (Interconnection Application Data sheet, found in Appendix B or C, must be attached to this Interconnection Application).

   b. Description of the equipment configuration and proposed interconnection one-line diagram (one-line diagram must be attached to this Interconnection Application).

   c. Project Developer (Single Point of Contact):

      Name: ______________________________

      Address: ______________________________

      ____

      Phone Number: ______________________________

      Fax Number: ______________________________

      e-mail Address: ______________________________

      Project Site Address: ______________________________

3. This Generator Interconnection Application shall be directed to the Utility representative as indicated below:

Director - Electric System Planning and Protection
Consumers Energy Company
1945 West Parnall Road
Jackson, MI 49201

4. I, the undersigned and authorized representative of the Project, submit this Generator Interconnection Application and required technical data for the Utility. I understand that upon acceptance, the Utility shall subsequently provide an Interconnection Study Agreement, if said Interconnection Study is determined to be necessary. The Interconnection Study Agreement will include the Scope of the Interconnection Study. I also understand that I shall be required to furnish certain required technical data as requested by the Utility in support of this study and reimburse the Utility for its study expenses.

Authorized Signature: ______________________________

Printed Name: ______________________________

Title: ______________________________

Company Name: ______________________________

Date: ______________________________

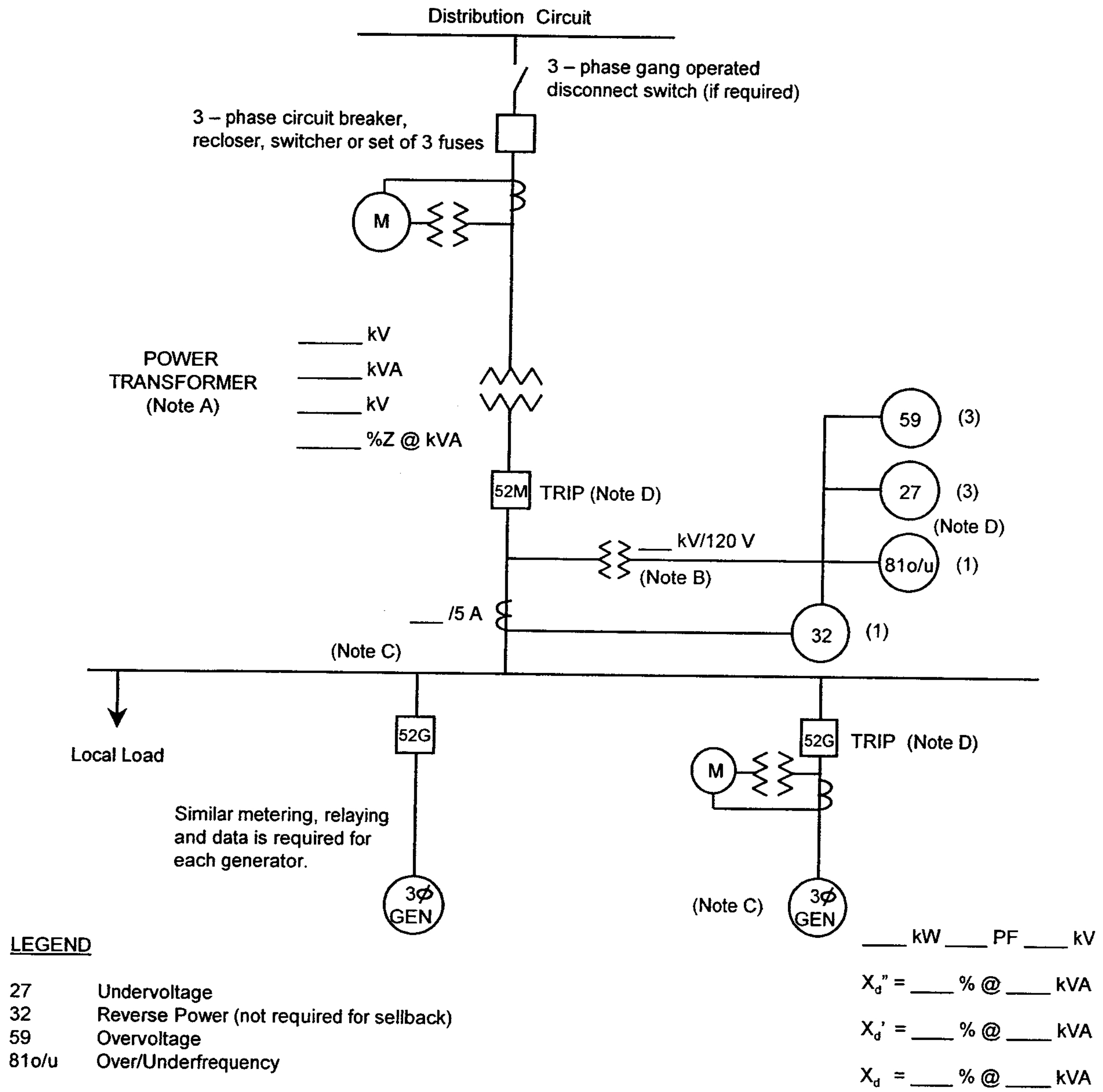
APPENDIX B

SYNCHRONOUS AND INDUCTION GENERATORS AGGREGATE GENERATION LESS THAN 30 kW

REQUIRED DATA

ONE-LINE REPRESENTATION

TYPICAL ISOLATION AND FAULT PROTECTION FOR SYNCHRONOUS GENERATOR INSTALLATIONS LESS THAN 30 kW



LEGEND

27	Undervoltage
32	Reverse Power (not required for sellback)
59	Overvoltage
81o/u	Over/Underfrequency

NOTES

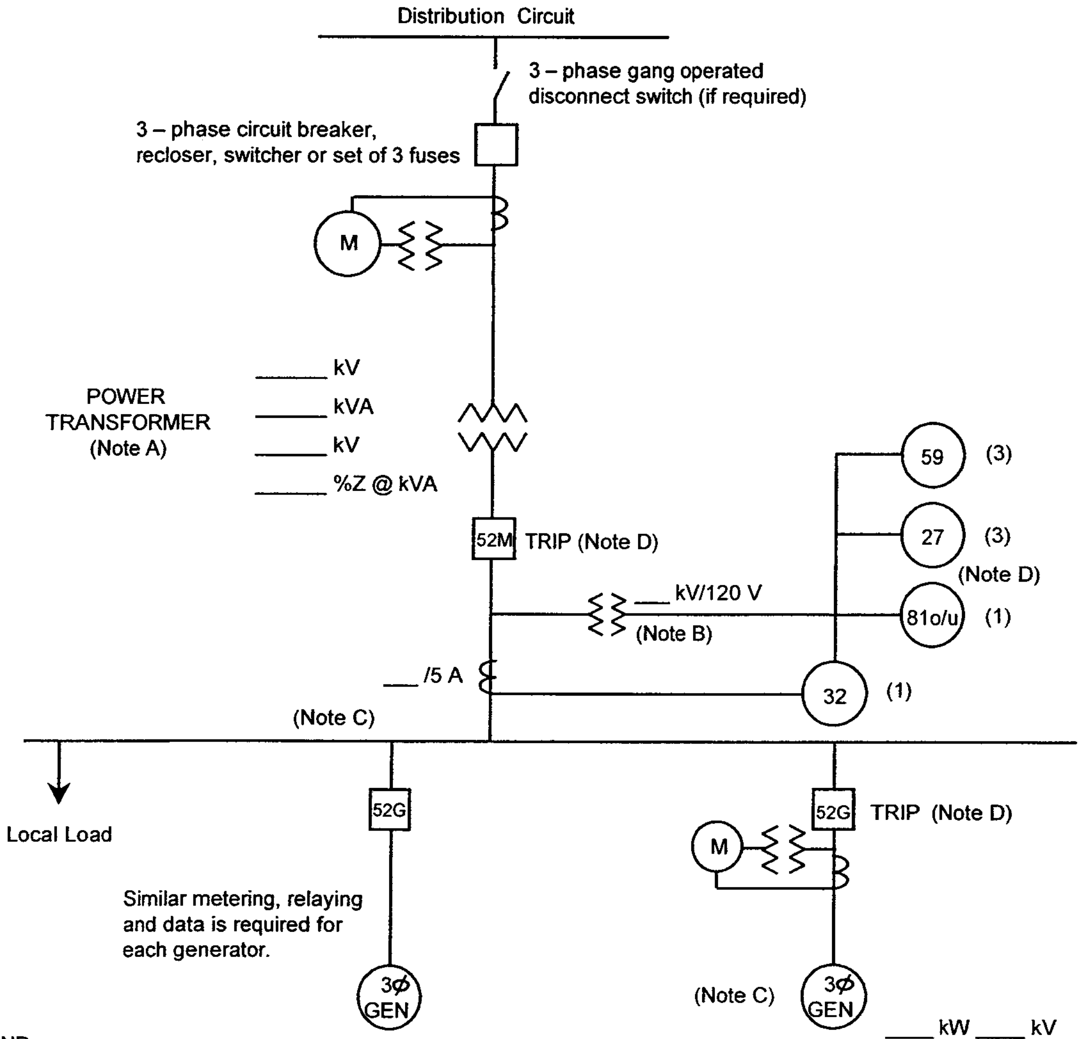
A) See technical requirements for permissible connection configurations and protection. Transformer connections proposed shall be shown on the one-line diagram by the Project Developer. Transformer connection and secondary grounding to be approved by Utility.

B) VTs for 59, 27, 81o/u and 32 are shown connected on the primary (Project side) of the power transformer, but may instead be connected on the secondary (Utility side). IEEE std 1547 requirements for voltage and frequency must be met at the PCC. IEEE Std. 1547 permits the VTs to be connected at the point of generator connection in certain cases.

C) Main breaker protection, generator protection and synchronizing equipment are not shown.

D) Trip of all 52G breakers or the 52M breaker is acceptable, depending upon whether the Project Developer wants to serve its own isolated load after loss of Utility service.

ONE-LINE REPRESENTATION
TYPICAL ISOLATION AND FAULT PROTECTION FOR INDUCTION GENERATOR INSTALLATIONS
LESS THAN 30 kW



LEGEND

27	Undervoltage
32	Reverse Power (not required for sellback)
59	Overvoltage
81o/u	Over/Underfrequency

NOTES

A) See technical requirements for permissible connection configurations and protection. Transformer connections proposed shall be shown on the one-line diagram by the Project Developer. Transformer connection and secondary grounding to be approved by Utility.

B) VTs for 59, 27, 81o/u and 32 are shown connected on the primary (Project side) of the power transformer, but may instead be connected on the secondary (Utility side). IEEE std 1547 requirements for voltage and frequency must be met at the PCC. IEEE Std. 1547 permits the VTs to be connected at the point of generator connection in certain cases.

C) Main breaker protection, generator protection and synchronizing equipment are not shown.

D) Trip of all 52G breakers or the 52M breaker is acceptable, depending upon whether the Project Developer wants to serve its own isolated load after loss of Utility service.

SYNCHRONOUS OR INDUCTION GENERATORS – AGGREGATE < 30 kW
INTERCONNECTION APPLICATION DATA FOR: ______________________
PROVIDED BY: ______________________________ DATE: ______________

Instructions: Attach data sheets as required. Indicate in the table below the page number of the attached data on which the requested information is provided.

General Information

Item No	Data Description	Attached Page No
1	Flow-back or Non-Flow-back	
2	Project Type (Base load, peaking, intermediate)	
3	Site Plan	
4	Simple One-Line Diagram(s) for Project and Project Load	
5	Detailed One-Line Diagram(s) for Project	
6	Energization Date for Project Interconnection Facilities	
7	First Parallel Operation Date for Testing	
8	Project Commercial Operation Date	
9	Estimated Project Cost	

The following information on these system components shall appear on the preliminary One-Line Diagram, including manufacturer make and model for the items listed below:

- Breakers - Rating, location and normal operating status (open or closed)
- Buses - Operating voltage
- Capacitors - Size of bank in kVAR
- Current Transformers - Overall ratio, connected ratio
- Fuses - normal operating status, rating (Amps), type
- Generators - Capacity rating (kVA), location, type, method of grounding
- Grounding Resistors - Size (ohms), current (Amps)
- Isolating transformers - Capacity rating (kVA), location, impedance, voltage ratings, primary and secondary connections and method of grounding
- Potential Transformers - Ratio, connection
- Reactors - Ohms/phase
- Relays - Types, quantity, IEEE device number, operator lines indicating the device initiated by the relays.
- Switches - Location and normal operating status (open or closed), type, rating
- Tagging Point - Location, identification

SYNCHRONOUS OR INDUCTION GENERATORS – AGGREGATE < 30 kW
INTERCONNECTION APPLICATION DATA FOR: ______________________
PROVIDED BY: ______________________________ DATE: _______________

Instructions: Attach data sheets as required. Indicate in the table below the page number of the attached data (manufacturer's data where appropriate) on which the requested information is provided. Provide one table for each unique generator.

Electric Generator(s) at the Project: Generator No _____

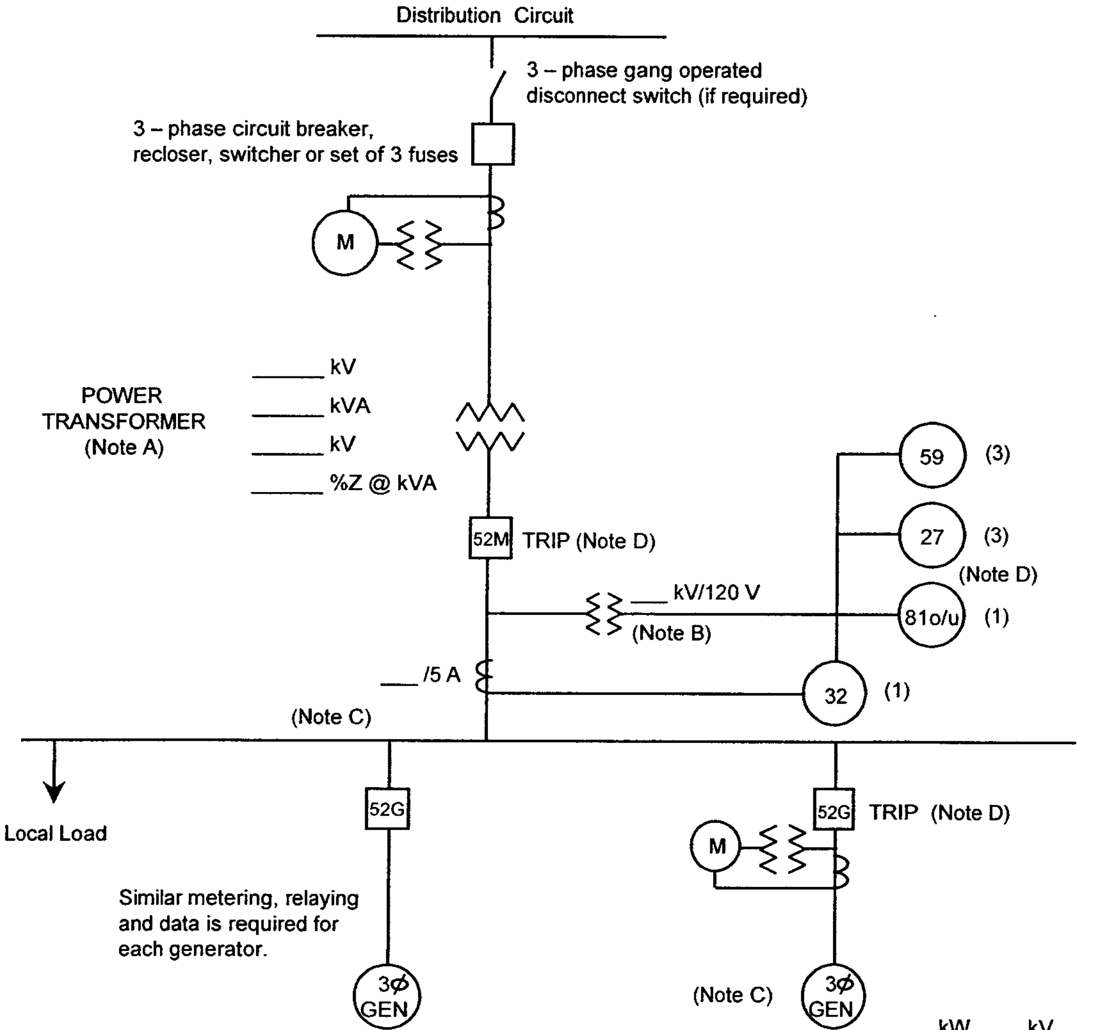
Item No	Data Value	Data Description	Attached Page No
1		Generator Type (synchronous or induction)	
2		Generator Nameplate Voltage	
3		Generator Nameplate Watts or Volt-Amperes	
4		Generator Nameplate Power Factor (pf)	
5		Short Circuit Current contribution from generator at the Point of Common Coupling (single-phase and three-phase)	
6		National Recognized Testing Laboratory Certification	
7		Written Commissioning Test Procedure	

APPENDIX C

INVERTER-TYPE GENERATORS
AGGREGATE GENERATION LESS THAN 30 kW

REQUIRED DATA

ONE-LINE REPRESENTATION
TYPICAL ISOLATION AND FAULT PROTECTION FOR INVERTER GENERATOR INSTALLATIONS
LESS THAN 30 kW



LEGEND

27	Undervoltage
32	Reverse Power (not required for sellback)
59	Overvoltage
81o/u	Over/Underfrequency

NOTES

A) See technical requirements for permissible connection configurations and protection. Transformer connections proposed shall be shown on the one-line diagram by the Project Developer. Transformer connection and secondary grounding to be approved by Utility.

B) VTs for 59, 27, 81o/u and 32 are shown connected on the primary (Project side) of the power transformer, but may instead be connected on the secondary (Utility side). IEEE std 1547 requirements for voltage and frequency must be met at the PCC. IEEE Std. 1547 permits the VTs to be connected at the point of generator connection in certain cases.

C) Main breaker protection, generator protection and synchronizing equipment are not shown.

D) Trip of all 52G breakers or the 52M breaker is acceptable, depending upon whether the Project Developer wants to serve its own isolated load after loss of Utility service.

INVERTER-TYPE GENERATORS – AGGREGATE < 30 kW
INTERCONNECTION APPLICATION DATA FOR: ______________________
PROVIDED BY: ____________________________ DATE: ______________

Instructions: Attach data sheets as required. Indicate in the table below the page number of the attached data on which the requested information is provided.

General Information

Item No	Data Description	Attached Page No
1	Flow-back or Non-Flow-back	
2	Project Type (Base load, peaking, intermediate, other)	
3	Site Plan	
4	Simple One-Line Diagram(s) for Project and Project Load	
5	Detailed One-Line Diagram(s) for Project	
6	Energization Date for Project Interconnection Facilities	
7	First Parallel Operation Date for Testing	
8	Project Commercial Operation Date	
9	Estimated Project Cost	

The following information on these system components shall appear on the preliminary One-Line Diagram, including manufacturer make and model for the items listed below:

- Breakers - Rating, location and normal operating status (open or closed)
- Buses - Operating voltage
- Capacitors - Size of bank in kVAR
- Current Transformers - Overall ratio, connected ratio
- Fuses - normal operating status, rating (Amps), type
- Generators - Capacity rating (kVA), location, type, method of grounding
- Grounding Resistors - Size (ohms), current (Amps)
- Isolating transformers - Capacity rating (kVA), location, impedance, voltage ratings, primary and secondary connections and method of grounding
- Potential Transformers - Ratio, connection
- Reactors - Ohms/phase
- Relays - Types, quantity, IEEE device number, operator lines indicating the device initiated by the relays.
- Switches - Location and normal operating status (open or closed), type, rating
- Tagging Point - Location, identification

INVERTER-TYPE GENERATORS – AGGREGATE < 30 kW
INTERCONNECTION APPLICATION DATA FOR: ______________________
PROVIDED BY: ______________________________ DATE: ______________

Instructions: Attach data sheets as required. Indicate in the table below the page number of the attached data (manufacturer's data where appropriate) on which the requested information is provided. Provide one table for each unique generator.

Electric Generator(s) at the Project: Generator No _____

Item No	Data Description	Attached Page No
1	Generator Type (Inverter)	
2	Generator Nameplate Voltage	
3	Generator Nameplate Watts or Volt-Amperes	
4	Generator Nameplate Power Factor (pf)	
5	Short Circuit Current contribution from generator at the Point of Common Coupling (single-phase and three-phase)	
6	National Recognized Testing Laboratory Certification	
7	Written Commissioning Test Procedure	

APPENDIX D

INTERCONNECTION STUDY AGREEMENT

[Utility]

[Project]

Interconnection Study Agreement for

Generator Interconnection

with Aggregate Project Output Below 30 kW

WHEREAS, proposals to construct or upgrade a Project which will be operated in parallel with and interconnected with [Utility's] ("Utility") electric system must be reviewed by the Utility to determine how it will impact the Utility electric system.

WHEREAS, on ______________________, Utility received from ____________________________ ("Project Developer") a Generator Interconnection Application.

WHEREAS Utility has determined that an Interconnection Study is necessary to determine whether the Utility electric system can accommodate the requested interconnection.

NOW, THEREFORE, in consideration of the mutual covenants and agreements herein set forth, the Utility and the Project Developer agree as follows:

1. The Utility shall complete an Interconnection Study in accordance with the Utility Generator Interconnection Requirements and this Agreement.

2. The Utility is permitted by the Michigan Public Service Commission to charge the Project Developer for an Interconnection Study. The charges shall not exceed the lesser of either of the following:

   (a) 5% of the estimated total cost of the Project or,
   (b) $10,000

The Utility shall not charge the Project Developer if the Project's aggregate export capacity is less than 15% of the line section peak load and the Project does not contribute more than 25% of the maximum short circuit current at the point of interconnection. The Project Developer will be billed for the cost of the Interconnection Study at the conclusion of the Interconnection Study.

3. The Project Developer is to return this executed Interconnection Study Agreement to the Utility as soon as possible. The interconnection process will not proceed until the fully executed Interconnection Study Agreement is received.

4. The Utility shall supply a copy of the completed Interconnection Study to the Project Developer.

5. Any notice or request made to or by either Party regarding this Agreement shall be made to the representative of the other Party, or its designated agent, as indicated below.

Utility	Project Developer
Name ____________________	____________________
Company ____________________	____________________
Address 1 ____________________	____________________
Address 2 ____________________	____________________

IN WITNESS WHEREOF, the Parties have caused this Interconnection Study Agreement to be executed by their respective authorized officials.

By:	By:
(Signature)	(Signature)
(Typewritten or Printed Name)	(Typewritten or Printed Name)
Title	Title
Date	Date

APPENDIX E

INTERCONNECTION AND OPERATING AGREEMENT

Consumers Energy

One Energy Plaza, Jackson, MI 49201

GENERATOR INTERCONNECTION & OPERATING AGREEMENT FOR PROJECTS WITH AGGREGATE GENERATOR OUTPUT LESS THAN 30 kW

PART I

Project Developer Name: ____________________

Project Service Address: ____________________ Account #: ________

Township/County/City: ____________________ State:______ Zip Code:______

Project Developer Contact Name: ____________________

Telephone: ( ) ____________ Fax: ( ) ____________ E-mail: ____________

Mailing Address (if different): ____________________

Equipment Specifications: Make: ____________________ Model: ____________

Service Type: Single Phase / Three Phase (circle one) Voltage Level: ____________

This section is to be completed by a Consumers Energy representative.

Work Order Number: ____________________

Good Faith Estimate for Interconnection: $____________________

Electric Field Manager Location: ____________________

Part II, Terms and Conditions on the reverse side hereof are a part of this Agreement.
PROJECT DEVELOPER ACKNOWLEDGES HAVING READ SAID TERMS AND CONDITIONS.

PROJECT DEVELOPER	**CONSUMERS ENERGY**
By: ____________________ (Signature)	By: ____________________ (Signature)
Printed Name: ____________________	Printed Name: ____________________
Title: ____________________	Title: ____________________
	Effective Date: ____________________

PART II

TERMS AND CONDITIONS

This GENERATOR INTERCONNECTON & OPERATING AGREEMENT (hereinafter, this Agreement), is made and entered into as of the Effective Date identified in Part I, between Consumers Energy, a Michigan corporation, One Energy Plaza, Jackson, MI 49201, herein termed "Consumers", and the Project Developer, herein termed "Project Developer." Consumers and Project Developer are hereinafter sometimes referred to individually as "Party" and collectively as "Parties" where appropriate.

1. **Request for Service**: The Project Developer hereby requests to interconnect and operate in parallel a generation plant with aggregate generation of less than 30 kW ("Project"), as indicated in Part I, to Consumers' distribution system. In order to provide said interconnection, it may be necessary for Consumers to install certain Interconnection Facilities of which the general location and type of facilities are depicted in Exhibit 1 - Interconnection Diagram. Exhibit 1 shall also define the design and physical construction of all the Interconnection Facilities of which the Project Developer shall solely bear the costs. The Parties desire to enter into this Agreement for purposes, among others, of describing the Interconnection Facilities and associated appurtenances to interconnect the Project to Consumers' distribution system. This Agreement does not address the sale of electricity to or from Consumers.

2. **Deposit Requirements**: Prior to construction, Project Developer shall pay 50% of the good faith estimate, indicated in Part I. If during construction, Consumers determines that the cost of the Interconnection Facilities varies significantly from the original good faith estimate, Consumers will notify the Project Developer in writing. Consumers shall have the right to delay or suspend all construction of its Interconnection Facilities until Project Developer responds to the notice. If the Project Developer's response and acceptance of this new cost estimate is not received within **5 business days**, Consumers may terminate this Agreement by written notice to the Project Developer. Upon such termination, Consumers will refund, without interest, the Project Developer's payment, less any expenses incurred to provide interconnection service to the location described in Part I of this Agreement.

3. **Payment Schedule**:

Payment	Amount Due	Milestone Description	**Target Due Date** (Number of Weeks from Completion of Application)
1	50% or $ figure	Execution of Generator Interconnection & Operating Agreement	0
2	50% or $ figure	Construction Complete	2
	$________	Good Faith Estimate Total	
	True-up (invoice or refund)	Three weeks after Construction Complete	5

All payments shall be made payable to Consumers and shall be sent to Consumers Energy Company, Attention: Treasurer, One Energy Plaza, Jackson, MI 49201, or by wire transfer to a Consumers' bank account or such other manner or at such place as Consumers shall, from time to time, designate by notice to Project Developer. Payments made by wire transfer shall reference the appropriate invoice number for which payment is being made. When Consumers has determined that all costs and expenses are accounted for on its books, Consumers will issue a final invoice or credit to reconcile the good faith estimate with the final work order estimate of the interconnection. The final work order estimate will be reviewed and reconciled to the good faith estimate for each portion of the interconnection covered under this Agreement. If Consumers' final work order estimates are less than the good faith estimate provided in Part I, Consumers shall refund the incremental amount to Project Developer. If Consumers' final work order estimates are greater than the good faith estimate provided in Part I, Consumers shall issue a final invoice to the Project Developer for the incremental amount. Any payment not made on or before the due date shall bear interest, from the date due until the date upon which payment is made, at an annual percentage rate of interest equal to the lesser of (a) the prime rate published by the Wall Street Journal (which represents the base rate on corporate loans posted by at least 75% of the nation's banks) on the date due, plus 2%, or (b) the highest rate permitted by law.

4. **Site Preparation/Access**: At its own expense, the Project Developer shall make the proposed Project site available to Consumers. Said site shall be free from hazard and shall be adequate for the operation and construction of the Interconnection Facilities necessary to connect the proposed Project. Consumers, its agents and employees, shall have full right and authority of ingress and egress at all reasonable times on and across the premises of the Project for the purpose of installing, operating, maintaining, inspecting, replacing, repairing, and removing its Interconnection Facilities located on the premises. The right of ingress and egress, however, shall not unreasonably interfere with Project Developer's use of its premises.

5. **Easements/Permits**: If necessary, prior to the installation of the Interconnection Facilities and anytime thereafter, Consumers will acquire required permits and necessary easements for its Interconnection Facilities. These easements / permits may include, but shall not be limited to, easements to clear trees, and necessary rights-of-way for installation and maintenance of its Interconnection Facilities. The Project Developer shall reimburse Consumers for its costs and expenses for acquiring such easements / permits.

6. **Parallel Operation:** It is understood that the Project will normally remain connected to and be operated in parallel with Consumers' distribution system. The Project Developer shall, at its expense, install and properly maintain protective equipment and devices and provide sufficiently trained personnel to protect its equipment and service, and the equipment and service of Consumers from damage, injury or interruptions during the Project's parallel operation with Consumers' distribution system, and, without limiting the indemnity provided in Section 12, will assume any loss, liability or damage to the Project caused by lack of or failure of such protection. Such protective equipment specifications and design shall be consistent with the Michigan Electric Utility Generator Interconnection Requirements and any successor and/or supplemental documents, incorporated herein by reference. Prior to the Project operating in parallel with Consumers' distribution system, the Project Developer shall provide satisfactory evidence to Consumers that it has met the Michigan Electric Utility Generator Interconnection Requirements that are on file with the Michigan Public Service Commission. These Michigan Electric Utility Generator Interconnection Requirements include, but are not limited to, approval from the local building code inspector.

7. **Testing:** The Project Developer shall perform operational testing and inspection of the Project at least 5 days before interconnection. The Project Developer shall contact Consumers and arrange for a mutually agreeable time for performing said tests. Consumers may send qualified personnel to the Project site to inspect the Project and observe the testing. Project Developer shall provide Consumers a written test report when such testing and inspection is completed and prior to interconnection. Protective relay equipment shall be tested every two (2) years (unless an extension is agreed to by Consumers) to verify the calibration indicated on the latest relay setting document issued by Consumers. Tests shall be conducted or witnessed by Consumers at Project Developer's expense. The results of such tests shall be provided to Consumers in writing for review and approval. Consumers may, at any time and at Consumers' expense, inspect and test the Project to verify that the required protective interconnection equipment is in service, properly maintained, and calibrated to provide the intended protection. If necessary, this inspection may also include a review of Project Developer's pertinent records. Inspection, testing and / or approval by Consumers or the omission of any inspection, testing and/or approval by Consumers pursuant to this Agreement shall not relieve the Project Developer of any obligations or responsibility assumed under this Agreement.

8. **Obligation to Connect:** Consumers shall not be obligated to continue the interconnection to the Project if any one or more of the following conditions exist, including but not limited to: (a) those conditions listed in the Miscellaneous Operational Requirements section of the Michigan Electric Utility Generator Interconnection Requirements, (b) the electrical characteristics of the Project are not compatible with the electrical characteristics of Consumers' distribution system, (c) the Project Developer is deficient in following either the voltage schedule or reactive power schedule established by Consumers, (d) an emergency condition exists on Consumers' distribution system, (e) Project Developer's protective relay equipment fails, resulting in a lack of the level of protection required by prudent utility practice, (f) the Project Developer's Project is determined to be disrupting Consumers customers or (g) Consumers requires disconnecting the Project in order to construct, install, maintain, repair, replace, remove, investigate, inspect or test any part of Consumers' Interconnection Facilities or any other Consumers equipment associated with the interconnection (also if a required component (example: phone line) or required modification to allow interconnection fails or becomes incapacitated and is not repaired in a timely manner). Consumers shall electrically connect or reconnect its distribution system to the Project when, in Consumers' sole opinion, the conditions named above cease to exist. Under any of the conditions listed above, Consumers will follow the agreed upon procedures for disconnecting and re-connecting the interconnection as outlined in Appendix F of the appropriate Michigan Electric Utility Generator Interconnection Requirements document.

9. **Subcontractors:** Either Party may hire a subcontractor to perform its obligations under this Agreement. However, each Party shall require its subcontractors to abide by the terms of this Agreement. Each Party shall remain primarily liable to the other Party for the performance of such subcontractor. Hiring a subcontractor does not release either Party from any of its obligations.

10. **Force Majeure:** Neither Party shall be considered to be in Default with respect to any obligation hereunder other than the obligation to pay money when due, if prevented from fulfilling such obligation by Force Majeure. A Party unable to fulfill any obligation hereunder (other than an obligation to pay money when due) by reason of Force Majeure shall give notice and the full particulars of such Force Majeure to the other Party in writing or by telephone as soon as reasonably possible after the occurrence of the cause relied upon. Telephone notices given pursuant to this article shall be confirmed in writing as soon as reasonably possible and shall specifically state full particulars of the Force Majeure, the time and date when the Force Majeure occurred and when the Force Majeure is reasonably expected to cease. The Party affected shall exercise due diligence to remove such disability with reasonable dispatch, but shall not be required to accede or agree to any provision not satisfactory to it in order to settle and terminate a strike or other labor disturbance.

11. **Assignment**: This Agreement shall not be assigned by the Project Developer except with the previous written consent of Consumers and any attempted assignment without such consent shall be void.

12. **Indemnity:** Each Party shall at all times assume all liability for, and shall indemnify and save the other Party harmless from, any and all damages, losses, claims, demands, suits, recoveries, costs, legal fees, and expenses for injury to or death of any person or persons whomsoever occurring on its own system, or for any loss, destruction of or damage to any property of third persons, firms, corporations or other entities occurring on its own system, including environmental harm or damage arising out of or resulting from, either directly or indirectly, its own Interconnection Facilities, or arising out of or resulting from, either directly or indirectly, any electric energy furnished to it hereunder after such energy has been delivered to it by such other Party, unless caused by the sole negligence or intentional wrongdoing of the other Party. The provisions of this Section 12 shall survive termination or expiration of this Agreement.

13. **Insurance:** Project Developer shall obtain and continuously maintain throughout the term of this Agreement liability insurance covering bodily injury and property damage liability with a per occurrence and annual policy aggregate amount of at least:

Project Capacity	**Minimum Limit**
Less than 30 kW	$500,000

When requested in writing by Consumers, said limit shall be increased each year that this Agreement is in force to a limit no greater than the amount arrived at by increasing the original limit by the same percentage change as the Consumer Price Index - All Urban Workers (CPI-U.S. Cities Average). Such policy shall include, but not be limited to, contractual liability for indemnification assumed by Project Developer under this Agreement.

Evidence of insurance coverage on a certificate of insurance shall be provided to Consumers upon execution of this Agreement and thereafter within ten (10) days after expiration of coverage; however, if evidence of insurance is not received by the 11th day, Consumers has the right, but not the duty, to purchase the insurance coverage required under this Section and to charge the annual premium to Project Developer. Consumers shall receive thirty (30) days advance written notice if the policy is cancelled or substantial changes are made that affect the additional insured. At Consumers' request, Project Developer shall provide a copy of the policy to Consumers. All certificates and notices shall be mailed to:

Consumers Energy Company
One Energy Plaza
Jackson, MI 49201
Attention: Corporate Insurance Department

14. **Limitation on Liability**: NEITHER PARTY SHALL IN ANY EVENT BE LIABLE TO THE OTHER FOR ANY INCIDENTAL OR CONSEQUENTIAL DAMAGES SUCH AS, BUT NOT LIMITED TO, LOST PROFITS, REVENUE OR GOOD WILL, INTEREST, LOSS BY REASON OF SHUTDOWN OR NON-OPERATION OF EQUIPMENT OR MACHINERY, INCREASED EXPENSE OF OPERATION OF EQUIPMENT OR MACHINERY, COST OF PURCHASED OR REPLACEMENT POWER OR SERVICES OR CLAIMS BY CUSTOMERS, WHETHER SUCH LOSS IS BASED ON CONTRACT, WARRANTY, NEGLIGENCE, STRICT LIABILITY OR OTHERWISE, EVEN IF IT HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

15. **Governing Law**: This Agreement shall be deemed to be a Michigan contract and shall be construed in accordance with and governed by the laws of Michigan, exclusive of its conflict of laws principles. In the event that any change in law or administrative rule or regulation that would materially alter the terms and conditions of this Agreement, either Party shall have the right to seek modification of this Agreement without prior written consent of the other Party.

16. **Effective Date, Term, and Termination:** The Effective Date of this Agreement shall be the date of execution, as identified in Part I, and shall continue in effect until this Agreement is terminated as provided herein. The Agreement may be terminated at any time by mutual agreement of both Parties, or by either Party upon giving the other at least ninety (90) days written notice if one or more of the conditions exist as outlined in Section 8, Obligation to Connect.

17. **Retirement:** Upon termination of this Agreement pursuant to Section 16 or at such time after any of the Interconnection Facilities described herein are no longer required, then the need for the retirement of said Interconnection Facilities shall be mutually determined by the Parties. Retirement of said Interconnection Facilities may include without limitation (i) dismantling, demolition, and removal of equipment, facilities, and structures, (ii) security, (iii) maintenance and (iv) disposing of debris. The cost of such removal shall be borne by the Party owning such Interconnection Facilities.

18. **Breach and Default:** A breach of this Agreement ("Breach") shall occur upon the failure of a Party to perform or observe any material term or condition of this Agreement. A default of this Agreement ("Default") shall occur upon the failure of a Party in Breach of this Agreement to cure such Breach. Examples of Default include, but are not limited to:

    a. Failure to pay money when due;
    b. Failure to comply with any material term or condition of this Agreement, including but not limited to any material Breach of a representation, warranty or covenant made in this Agreement;
    c. A Party: (i) becomes insolvent; (b) files a voluntary petition in bankruptcy under any provision of any federal of state bankruptcy law or shall consent to the filing of any bankruptcy or reorganization petition against it under any similar law; (c) makes a general assignment for the benefit of its creditors or (d) consents to the appointment of a receiver, trustee, or liquidator;
    d. Assignment of this Agreement in a manner inconsistent with the terms of this Agreement;
    e. Failure of either Party to provide such access rights, or a Party's attempt to revoke or terminate such access rights, as provided under this Agreement;
    f. Failure of either Party to provide information or data to the other Party as required under this Agreement, provided the Party entitled to the information or data under this Agreement requires such information or data to satisfy its obligations under this Agreement.

    In the event of a Breach or Default by either Party, the Parties shall continue to operate and maintain, as applicable, its Interconnection Facilities, including but not limited to: protection and Metering Equipment, transformers, communication equipment, building facilities, software, documentation, structural components and other facilities and appurtenances that are reasonably necessary for Consumers to operate and maintain its distribution system and for the Project Developer to operate and maintain its Project in a safe and reliable manner. Upon a Default, the non-defaulting Party shall give written notice of such Default to the defaulting Party. The defaulting Party then has 30 days to cure the Default. If a Default is not cured within the period provided for herein or as agreed to by the Parties, the non-defaulting Party shall have the right to terminate this Agreement by written notice and shall be relieved of any further obligations hereunder. Further, in the event of such termination, the non-defaulting Party shall be entitled to recover from the defaulting Party all amounts due hereunder, plus all other damages and remedies to which it is entitled at law or in equity. The provisions of this Section 18 will survive termination of this Agreement.

19. **No Partnership:** This Agreement shall not be interpreted or construed to create an association, joint venture, agency relationship, or partnership between the Parties or to impose any partnership obligation or partnership liability upon either Party. Neither Party shall have any right, power or authority to enter into any agreement or undertaking for, or act on behalf of, or to act as or be an agent or representative of, or to otherwise bind, the other Party.

20. **Severability:** If any provision or portion of this Agreement shall for any reason be held or adjudged to be invalid or illegal or unenforceable by any court of competent jurisdiction or other governmental authority, (1) such portion or provision shall be deemed separate and independent, (2) the Parties shall negotiate in good faith to restore insofar as practicable the benefits to each Party that were affected by such ruling, and (3) the remainder of this Agreement shall remain in full force and effect.

21. **Entire Agreement:** This Agreement and the Michigan Electric Utility Generator Interconnection Requirements shall constitute the entire understanding between the Parties with respect to the subject matter hereof, supersede any and all previous understandings between the Parties with respect to the subject matter hereof, and binds and insures to the benefit of the Parties, their successors, and permitted assigns. No amendments or changes to this Agreement shall be binding unless made in writing and duly executed by both Parties.

22. **No Third Party Beneficiaries:** This Contract is intended for the benefit of the parties hereto and does not grant any rights to any third parties unless otherwise specifically stated herein.

23. **Notices**: All notices required hereunder shall be in writing and shall be sent by United States mail or delivered in person to the Parties at their respective addresses as set forth in Part I. Either Party may at any time change the addressee or address to which notices to it are to be mailed or delivered by giving notice of such change to the other Party. All Notices shall become effective upon date of receipt.

24. **Waivers:** Consumers may apply for a waiver from one (1) or more provisions of the Michigan Public Service Commission's "Department of Consumer and Industry Services Public Service Commission Electric Interconnection Standards." The Michigan Public Service Commission may grant a waiver upon a showing of good cause.

25. **Other:** ____

____

____

____

____

____

____

EXHIBIT 1
INTERCONNECTION DIAGRAM

(Insert one of the eighteen One-Line Diagrams (PDF file) for the various size and type of generator that will be installed.)

APPENDIX F

CONTACT LIST

<u>CONTACT LIST</u>
Normal Operations and Emergency Switching

<u>GENERAL</u>

Switching and clearance procedures for Consumers Energy ('Consumers") and the Project Developer provides important documentation to ensure safe working conditions and orderly and reliable service when work is required on the Interconnection Facilities.

<u>PROCEDURE</u>

1. <u>Emergency Switching Procedure:</u>

Operating Authority for the Project Developer will be handled by the following "Priority Contact List."

a. Project Developer's Plant	( )
b. Project Operator (pager)	( )
or mobile	( )
c. 1st Contact Name (home phone)	( )
d. Second Contact:	If applicable
e. Third Contact:	If applicable

Operating Authority for Consumers will be the System Controller located in ________, Michigan. Telephone numbers are either ( ) or ( ) .

2. <u>Scheduled Outage Procedure:</u>

Request initiated by the Project Developer.

Operating Authority for the Project Developer will be (Contact Name), Project Operator or an authorized representative. (Contact Name) or an authorized representative will contact the System Control Scheduler to make the necessary arrangements and to agree on the switching procedures.

Request initiated by Consumers.

Scheduling Authority for Consumers will be the System Control Scheduler located in __________, Michigan. Contact numbers are either ( ) or ( ) .

The System Control Scheduler will contact (Contact Name) or an authorized representative to make necessary arrangements and to agree on switching procedures.

<u>NOTE</u>: Each authority will attempt to provide a minimum of 72 hours notice on scheduled outage requests, except in an emergency or imminent equipment failure.

IN WITNESS WHEREOF, the Parties hereto have executed this Agreement as of the Effective Date identified below.

(PROJECT DEVELOPER'S NAME)	CONSUMERS ENERGY
By ____________________	By ____________________
Title____________________	Title____________________
	Effective Date________________

APPENDIX B.4 CONTACT LIST

Team Member	Email	Contacted	From	Why Contacted	Email	Phone
Craig Baker	csb5	Lucas DeVries	Calvin College Physical Plant	Electrician	ldevries@calvin.edu	616-526-6859
Dan Nieuwenhuis	dan3	Daniel Slager	Calvin College Physical Plant	Electricity Bills	slagda@calvin.edu	616-526-6267
Eric DeVries	erd2	Bob Crow	Calvin College	Neighborhood coordinator	rcrow@calvin.edu	616-526-6165
Eric DeVries	erd2	Randy VanDrugt	Calvin College Professor	Nature Preserve	vdra@calvin.edu	616-526-6497
Geoff VanLeewen	gjv3	Garth Ward	Michigan Wind Power	Pricing information	michiganwindpower@yahoo.com	
Geoff VanLeewen	gjv3	Pierre Marcotte	SPM Windpower	Installing skystream in hastings	spmwindpower@earthlink.net	269.948.4398
Geoff VanLeewen	gjv3	Kim Wagner	Event Horizon Solar & Wind	Pricing information	solarpower@hughes.net	269.795.5285
Geoff VanLeewen	gjv3	Brian Taylor	Sundu Solar Energy LLC	Wind Map information	sundubrian@cablespeed.com	517.719.2492
Geoff VanLeewen	gjv3	Kevin Marwick	Cyclone Wind Power		info@windturbine.ca	
Geoff VanLeewen	gjv3	Mark Bauer	Bauer Power	Installing skystream in Muskeegon	mark@bauerpower.us	616.890.0019
Geoff VanLeewen	gjv3	NC Small Wind Initiative	Appalachian State University	They have two skystreams installed	wind@appstate.edu	828.262.7333
Jordan Beekhuis	jhb4	Deanna van Dijk	Calvin College Associate Prof.		dvandijk@calvin.edu	616-526-6510
Jordan Beekhuis	jhb4	Archie Gragg	Consumers Energy	Design Grid Systems	ahgragg@cmsenergy.com	616-530-4358
Josh Kroon	jkroon86		Gerald R. Ford International Airport			616-233-6000
LeAnne Bock	lnb2	Terry Schweitzer	Kentwood Zoning		schweitt@ci.kentwood.mi.us	
LeAnne Bock	lnb2	Chris Clement	Ottawa County Planner	Land Fills	cclement@co.ottawa.mi.us	616-738-4689
LeAnne Bock	lnb2	Sean Myers	Polkton Charter Township	Land Fills		616-837-6876
Shalomel Kundan	syk2	Phil L. deHaan	Calvin College	Director of Media Relations	dehp@calvin.edu	616-526-6475
Shalomel Kundan	syk2	Jay Laninga	Chief Financial Officer, GRCS	Electricity Usage	jlaninga@grcs.org	616-574-6376
Shalomel Kundan	syk2	Carol Rienstra	Calvin College	Director of Community Relations	crienstr@calvin.edu	616-526-6175
Management		Prof. Heun	SB140			
Management		Henry DeVries	HL306			
Management		Chuck Holwerda	SB039			
Management		Paul Pennock	Service Building 100			

APPENDIX C CONTENTS

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APPENDIX C.1 COST ANALYSIS

APPENDIX C.1.1 TURBINES

The turbine cost analysis is simply the cost of the turbine. The two recommended turbines, Skystream and Bergey XL1, cost $5,000 and $2,590 respectively.

APPENDIX C.1.2 TOWERS

The costs for the towers include the tower kit, piping, concrete, and soil testing. The tower kit includes the guy-wires, rebar, nuts and bolts. The piping is the actual tower pipe which can be purchased as a constructed tower or Calvin could use its own pipe to create a tower. The concrete is for the foundation of tower. The soil-testing is a requirement for any construction. The soil needs to be tested to determine whether the area is safe to build on and what precautions must be taken for different types of soil.

The four tower types we looked into were the 35' monopole, 35' lattice, 70' monopole, 70' lattice. A basic breakdown for the costs of each of these towers is shown in Figure C-1.

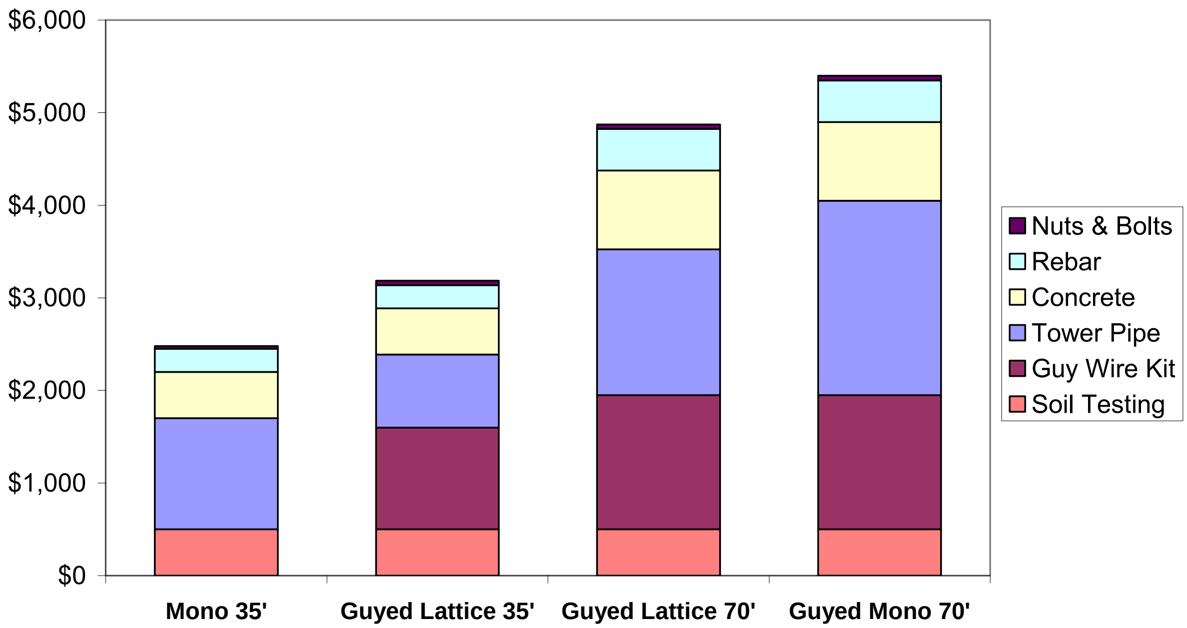


Figure C-1: Tower Cost Comparison

As shown in Figure C-1, the 35' Monopole is significantly less expensive because it does not require any guy-wires.

APPENDIX C.1.3 INFRASTRUCTURE

The budget of $11,000 was not only for the turbine and the tower costs. This budget had to be shared with the Infrastructure and external relations teams. The costs for the Infrastructure include the inverter, boring, transmission wire, data transmission hardware, and the bi-directional meter. We had to take these costs into consideration while determining our final recommendation because these costs were subject to change depending on the turbine, tower and site selections. Overall, the infrastructure costs for the Skystream and Bergey came to $3,939 and $5,939 respectively. The only difference in these costs was the need for an inverter for the Bergey which costs approximately $2,000. Other than that, the tower and site selections were constant so none of the other infrastructure costs changed.

APPENDIX C.1.4 TOTAL

The total costs for the Skystream and the Bergey are $11,419 and $11,010 respectively. Cost breakdowns for each of these recommendations are shown in Figures C-2 and C-3.

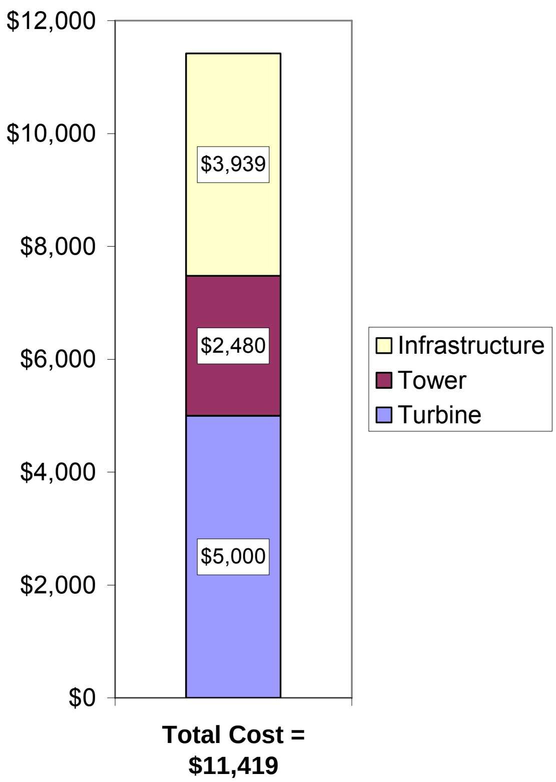


Figure C-2: Skystream Cost Breakdown

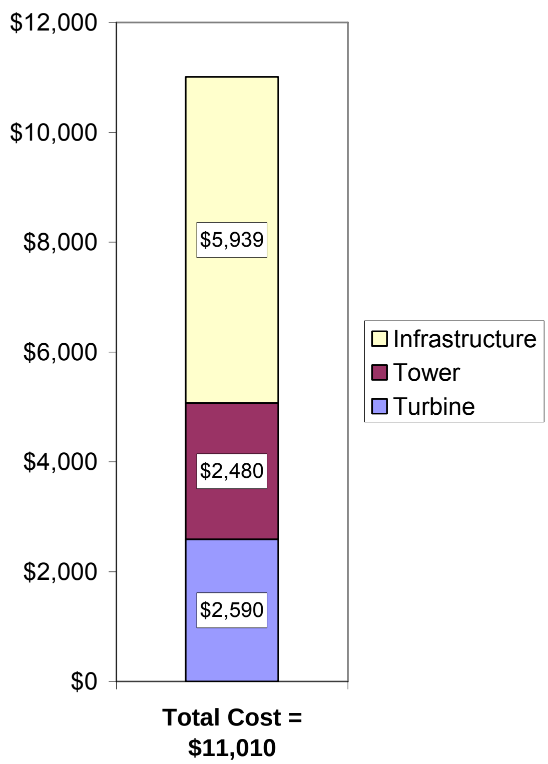


Figure C-3: Bergey XL.1 Cost Breakdown

APPENDIX C.2 TURBINES

APPENDIX C.2.1 SOUTHWEST SKYSTREAM 3.7

The Skystream 3.7 is the ideal selection for a turbine because it offers the highest rated output for the cost of the turbine. The Skystream has a rated output of 1.8 kW at a wind speed of 20 mph. Many other turbines with similar rated outputs have larger wind speed requirements. This lower wind speed fits our area well because of the generally low wind speeds. Finally, this turbine has a built-in inverter and does not have a gear-box. This design prevents purchasing a separate inverter and maintenance on a gear-box which tend to fail after about 5 years. Also, without a gear-box, the noise pollution from the turbine is greatly reduced.

APPENDIX C.2.2 BERGEY XL.1

The Bergey XL.1 is a good choice for a contingency plan because it comes from a very reputable company and there are many positive reviews on this particular turbine. It is rated as a 1 kW turbine at 24.6 mph. However, this turbine does not have a built-in inverter and it has a gear box that will eventually require maintenance.

APPENDIX C.3 TOWERS

The four possible tower choices include 35' Monopole, 35' Lattice, 70' Monopole, 70' Lattice. The key points for the tower selection include the environmental impact, height, aesthetics, and cost.

The 35' Monopole has little environmental impact because it does not require guy-wires. Also, because of the lack of guy-wires, this tower is more aesthetically pleasing and costs significantly less than the other towers. However, the height of 35' reduces the wind availability and therefore will reduce the average power output from the turbine.

The 35' Guyed Lattice tower does not have any advantages by comparison to other towers. It has a larger footprint than the monopole because of the guyed-wires; it is less aesthetically pleasing because it is lattice and because of the guy-wires. It does not offer any more wind availability than the 35' monopole. Finally, it even costs more than the 35' monopole because of the guy-wire kit.

The 70' Guyed Lattice tower has the same limitations as the 35' Guyed lattice except that at double the height it will offer more wind availability. However, the increased cost for this tower will put the project well over budget and can not be justified even with the potential power output increase.

The 70' Guyed Monopole would also increase the potential power output like the 70' guyed Lattice. This tower would also be more aesthetically pleasing and create a smaller footprint than the 70' guyed Lattice. However, this tower is the most expensive and would put the project over budget and can not be justified.

APPENDIX C.4 SITES

The Short Term Team chose four possible sites for the turbine. These are located on the east side of the East Beltline, far away from a majority of Calvin's campus. Figure C-4 below presents these sites.

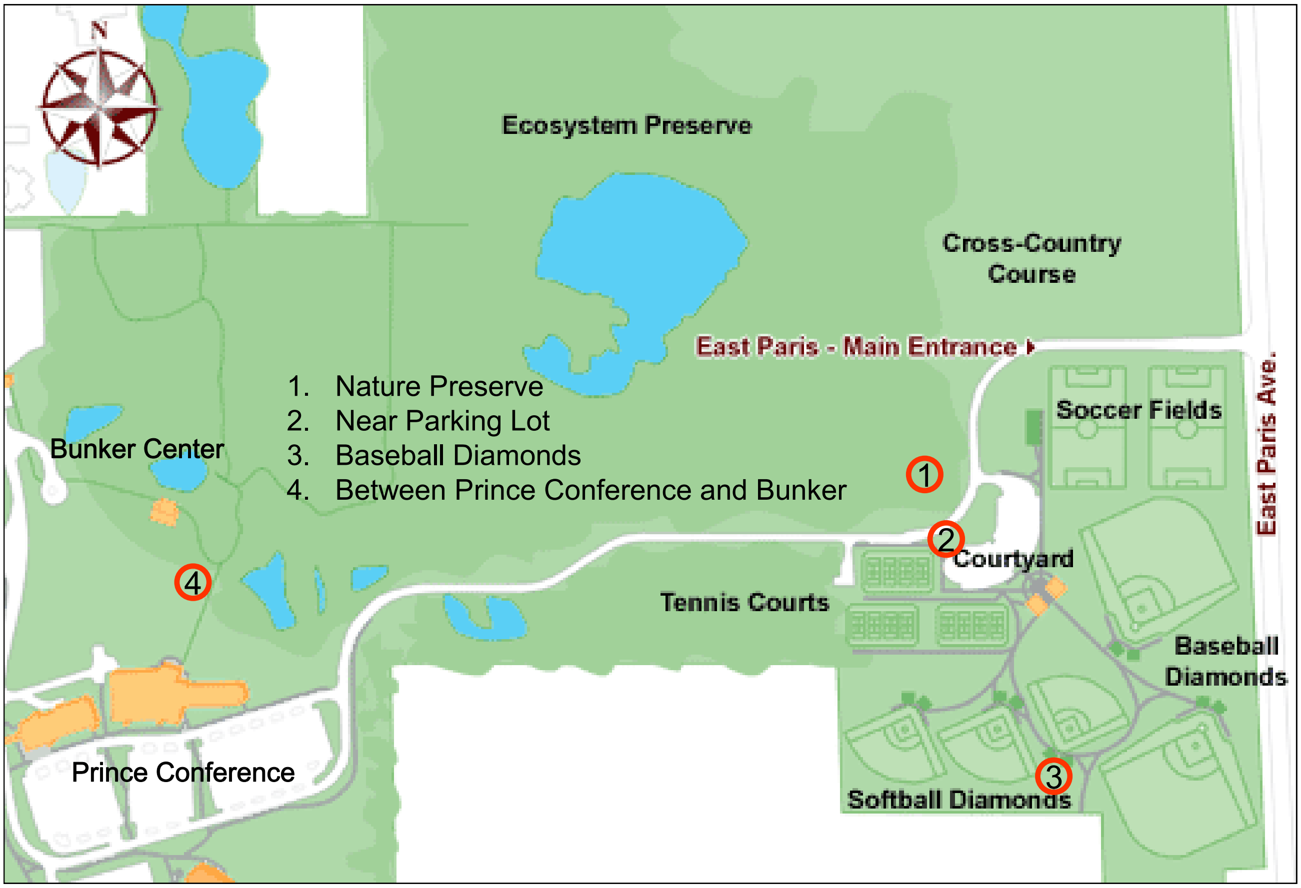


Figure C-4: Site Locations

The key points for the site selection include wind availability, public safety, public visibility, and grid connection.

Nature Preserve near Gainey Field This site is optimal for several reasons. The first is wind availability. Because Michigan has only class 3-4 wind resources, the recommended site needed to have few obstructions to insure an adequate wind supply during still times of the day. According to several sources, a turbine should be placed 20 feet above everything surrounding it within 200 feet. This location is extremely open. It even has a higher elevation than most of the nature preserve. However, Calvin College is constantly growing, requiring the consideration of future developments such as buildings and roads. By locating the turbine inside the nature preserve, Calvin can insure that no future developments will introduce limitations to wind resources.

This site is optimal because it provides public safety. Inside the nature preserve, the turbine will be enclosed by a small fence in addition to the main fence surrounding the perimeter of the preserve. This will keep pedestrians a safe distance away from the turbine at all times.

Gainey patrons serve as an additional set of people that will be exposed to this demonstration site. Drivers along East Paris also view the demonstration site.

This site is not ideal for grid connection. The Calvin grid doesn't go out to the Gainey fields, so the power cannot be used directly by Calvin. However, the tool shed is close enough to the turbine site.

Near Parking Lot of Gainey Field This site provided many similar benefits to the nature preserve. However, it didn't provide as much public safety, simply because it was located near the parking lot. It also didn't prevent the relocation of the turbine because the College's long term parking lot plans are uncertain in that location.

Between Baseball Diamonds near Church Of the Servant This site provided many similar benefits to the nature preserve. However, placing a turbine near sporting events introduces new issues regarding public safety and possible turbine damage.

Between Prince Center and Bunker Center This site has a local grid tie at the Bunker Interpretive Center. It also highlights that the wind turbine expands the Bunker's existing renewable energy focus. However, this site missed many benefits of the nature preserve. Future development of that site is almost certain, requiring relocation. In the end, the benefits didn't outweigh almost certain relocation.

APPENDIX C.5 REFERENCES

Name	Company	Email	Phone
Garth Ward	Michigan Wind Power	<michiganwindpower@yahoo.com>	
Pierre Marcotte	SPM Windpower	<spmwindpower@earthlink.net>	269.948.4398
Kim Wagner	Event Horizon Solar/Wind	<solarpower@hughes.net>	269.795.5285
Brian Taylor	Sundu Solar Energy LLC	<sundubrian@cablespeed.com>	517.719.2492
Kevin Marwick	Cyclone Wind Power	<info@windturbine.ca>	
Mark Bauer	Bauer Power	<mark@bauerpower.us>	616.890.0019
NC Small Wind Initiative	Appalachian State University	<wind@appstate.edu>	828.262.7333

SKYSTREAM 3.7™

1.8 KW Residential Power Appliance

Skystream 3.7 is a breakthrough in a new generation of RPA (Residential Power Appliances) that will change the energy landscape of how homes and small businesses receive electricity. Skystream is the first fully integrated system that produces energy for less than the average cost of electricity in the United States and it produces usable energy in exceptionally low winds.[1]

Skystream is available on towers ranging from 35 to 110 feet.[2] Its universal inverter will deliver power compatible with any utility grid from 110-240 VAC.[3] Skystream will efficiently and silently provide up to 100% of the energy needs for a home or small business. Any extra energy is fed into the grid spinning the meter backwards.[4]

Technical Specifications

Model: Skystream 3.7™

Rated Capacity: 1.8 kW **Weight:** 154 lbs / 70 kg

Rotor Diameter: 12 feet / 3.72 m **Swept Area:** 115.7 ft² / 10.87 m²

Type: Downwind rotor with stall regulation control

Direction of Rotation: Clockwise looking upwind

Blade Material: Fiberglass reinforced composite **Number of Blades:** 3

Rated Speed: 50-325 rpm **Tip Speed:** 66-213 f/s / 9.7-63 m/s

Alternator: Slotless permanent magnet brushless **Yaw Control:** Passive

Grid Feeding: Southwest Windpower inverter 120/240 VAC 50-60/Hz

Braking System: Electronic stall regulation with redundant relay switch control

Cut-in Wind Speed: 8 mph / 3.5 m/s **Rated Wind Speed:** 20 mph / 9 m/s

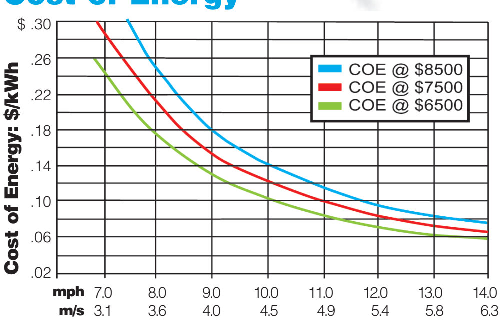
User Control: Wireless 2-way interface remote system

Survival Wind Speed: 140 mph / 63 m/s

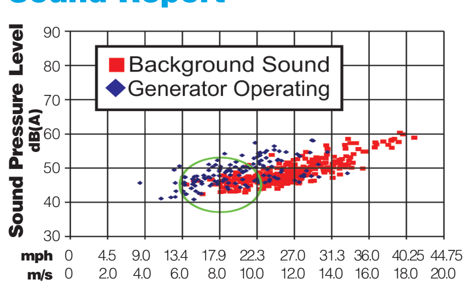
1. Based on a 12 mph (5.4 m/s) wind and utility energy cost of $.09/kWh
2. Taller towers are available
3. 120V will be available in the 4th quarter of 2006
4. Assuming the Skystream 3.7 is producing more energy than the load is consuming

MADE IN USA

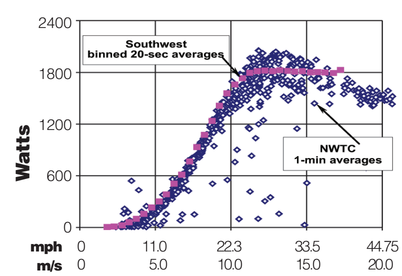
Cost of Energy



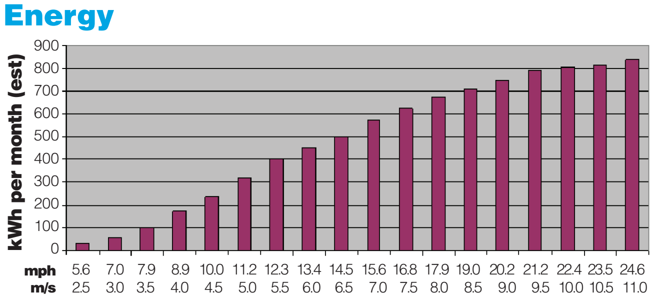
Sound Report



Performance Graph



Energy



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- Nearly Silent Operation
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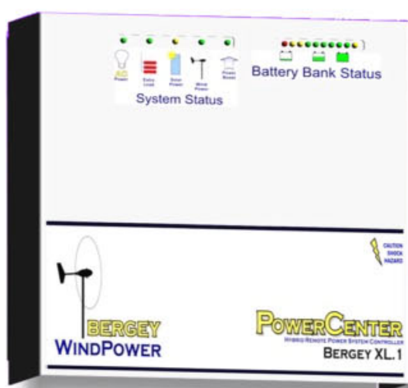
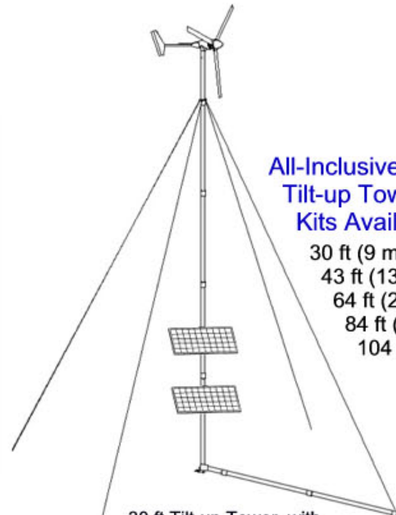
- State-of-the-Art Airfoil (Pat. Pending)
- Direct-Drive Neodymium PM Alternator
- PowerCenter® Multi-Function Controller
- Battery-Friendly OptiCharge Regulation
- Optional Integrated 500 W Sine Inverter
- Complete Tubular Tilt-up Towers Available
- Complete "Plug and Play" Systems Available

The Bergey XL.1 is the most technically advanced small wind turbine ever. It comes from the world's leading manufacturer of small wind turbines and is backed by a full 5-year warranty. The XL.1 wind turbine is designed for high reliability, low maintenance, and automatic operation in adverse weather conditions. And the XL.1's "all-in-one" PowerCenter provides complete hybrid system integration, including an optional on-board sine wave inverter. Owner installations are a snap with Tilt-up Tower options from 30 - 104 ft.

Easy to install, extremely reliable, and a solid value, the Bergey XL.1 is the clear choice for your home energy system.



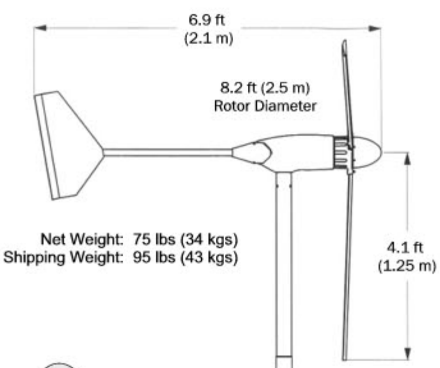
BWC XL.1 PowerCenter Controller



All-Inclusive Tilt-up Tower Kits Available:
30 ft (9 m)
43 ft (13 m)
64 ft (20 m)
84 ft (26 m)
104 ft (32 m)

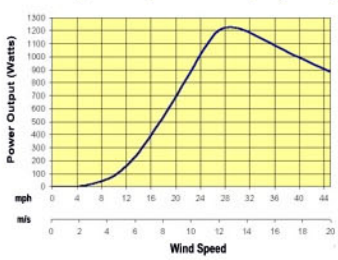
30 ft Tilt-up Tower, with Optional 200 W Solar Array

The Only Moving Parts Are The Parts You See Moving



Performance

Start-up Wind Speed ... 6.7 mph (3 m/s)
Cut-In Wind Speed ... 5.6 mph (2.5 m/s)
Rated Power ... 1,000 Watts
Rated Wind Speed ... 24.6 mph (11 m/s)
Rated Rotor Speed ... 490 RPM
Furling Wind Speed ... 29 mph (13 m/s)
Max. Design Wind Speed ... 120 mph (54 m/s)



Predicted Energy Production

Wind Speeds Taken at Top of Tower

Annual Average Wind Speed (m/s)		3.5	4	4.5	5	5.5	6	6.5
Annual Average Wind Speed (mph)		7.8	8.9	10.1	11.2	12.3	13.4	14.5
Production in kWh (24 VDC)	Daily	1.9	2.8	3.9	5.1	6.4	7.7	8.9
	Monthly	55	85	115	155	195	235	270
	Annually	680	1,010	1,410	1,850	2,320	2,790	3,260

Wind Speeds Taken at 10 meters (per standard wind resource maps)

US-DOE Wind Power Class			1	2	3	4	5	6	7
Annual Average Wind Speed (mph)			~ 8.9	~ 10.7	~ 12.1	~ 13.0	~ 13.9	~ 15.0	~ 18.8
Annual Average Wind Speed (m/s)			~ 4.0	~ 4.8	~ 5.4	~ 5.8	~ 6.2	~ 6.7	~ 8.4
Production in kWh (24 VDC)	30 ft (9m) Tower	Daily	2.6	4.3	5.8	6.8	7.8	9.1	12.7
		Monthly	80	130	175	205	240	275	385
	64 ft (20m) Tower	Daily	4.1	6.4	8.2	9.3	10.4	11.7	14.7
		Monthly	125	195	250	285	320	355	445
	104 ft (32m) Tower	Daily	5.2	7.8	9.7	10.9	12.0	13.1	15.4
		Monthly	160	235	295	330	365	400	465

Assumptions: Inland site, Rayliegh Wind Distrubution, Shear Exponent = 0.20, Altitude = 1000ft (300m).
Note: Battery charge regulation (batteries full) and wire run losses will reduce actual XL.1 performance.
Your Performance May Vary.

Dealer:

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APPENDIX D CONTENTS

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APPENDIX D.1 SITE SELECTION

APPENDIX D.1.1 ON CAMPUS LOCATION

The location on campus is located next to the Ecosystem Preserve on the Gainey Athletic Facility located on 1661 East Paris Ave. SE, Grand Rapids, MI 49546 which is owned by Calvin College.

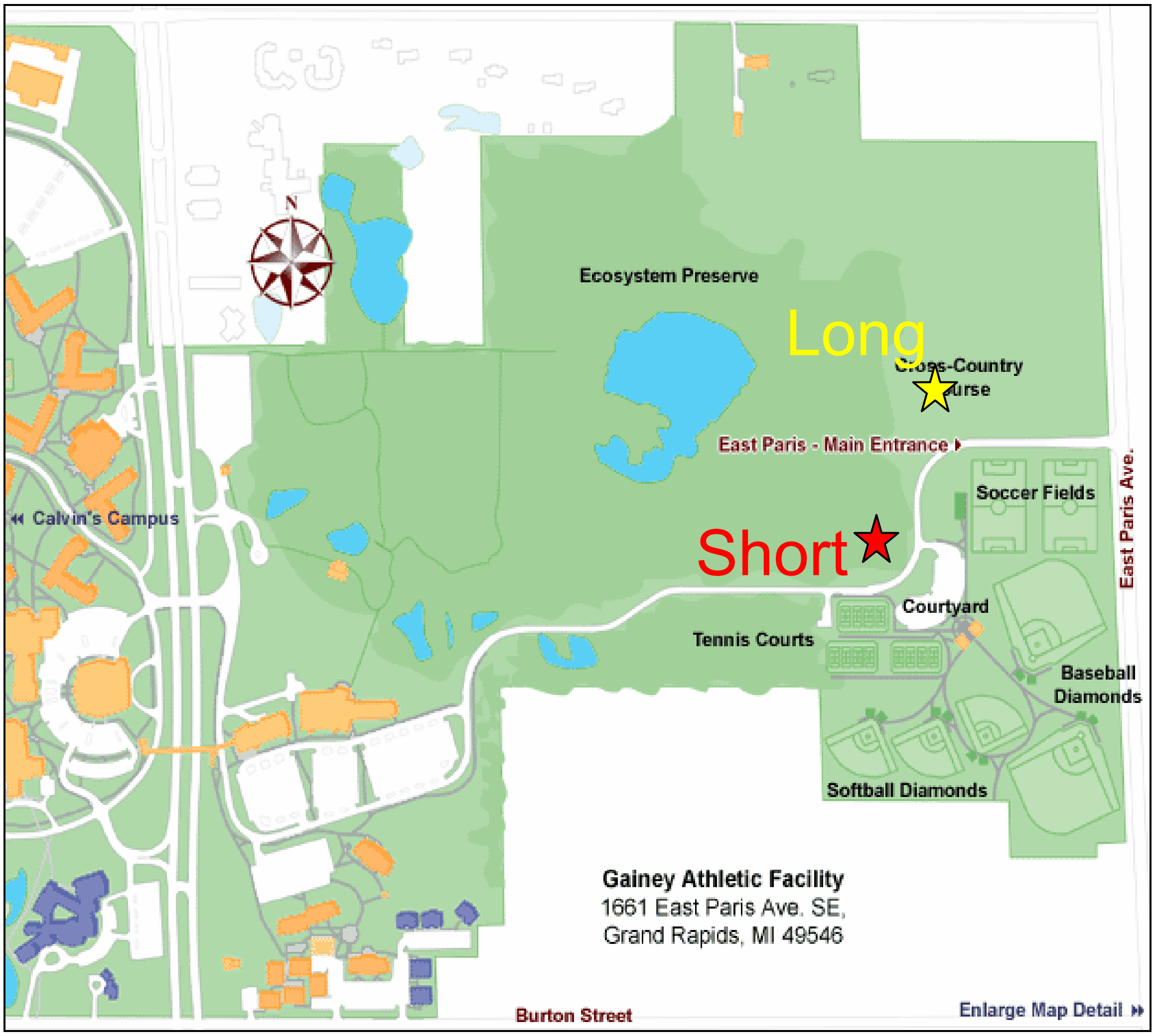


Figure D-1: On Campus Location

APPENDIX D.1.2 ACOUSTIC IMPACT

Figure D-2 shows two different circles, the darker circle denotes a 300m zone where the acoustic decibel level ranges from 35db to 90db. The lighter circle extends 100m from the 300m zone. In this area the acoustic levels are 35db or lower. It is important to know these values since the standard acceptability level is 40dB at any residence for a rural location and 45dB for an urban location. The Danish Wind Industry Association's models show that at 300 meters from the turbine the sound has dropped off below 40dB making noise levels acceptable for any surrounding residences. For a point of comparison 40dB is about the volume of a quiet office or bedroom and 30dB being the noise level made from rustling leaves.

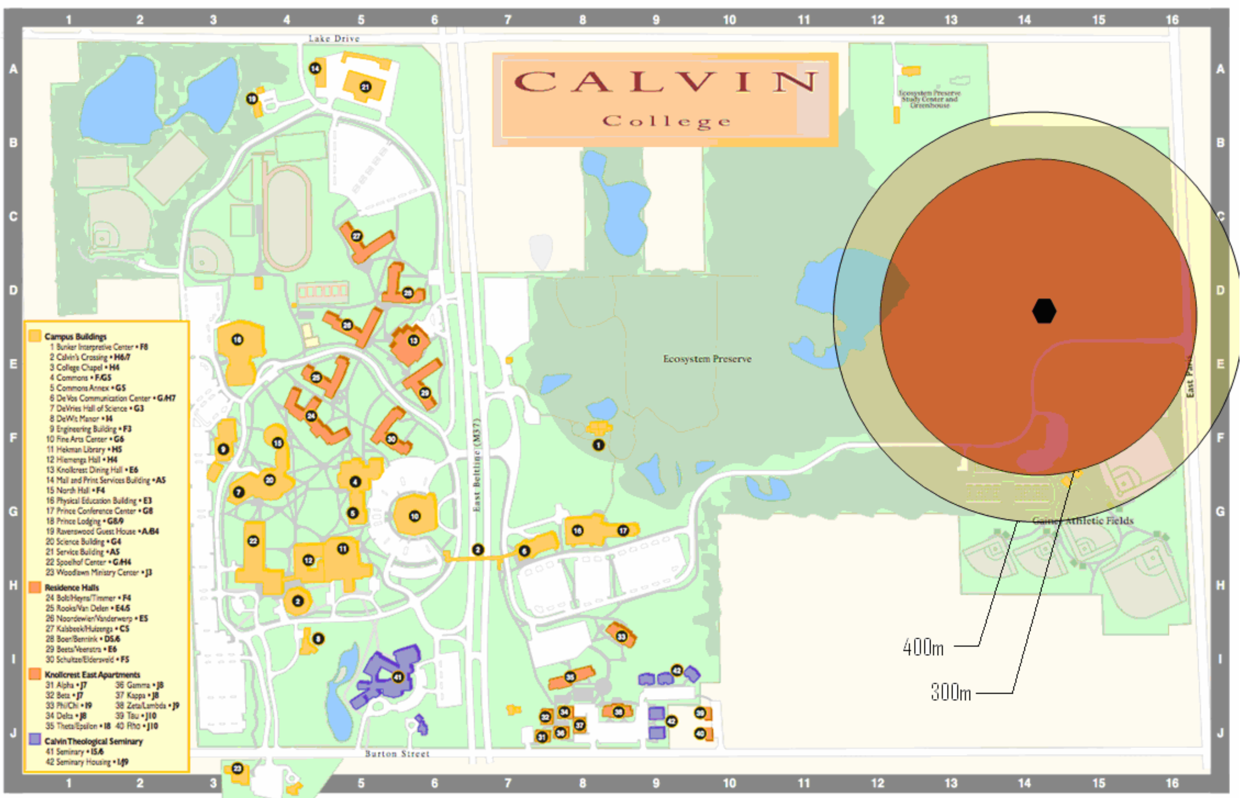


Figure D-2: Turbine Sound Casting

APPENDIX D.1.3 TURBINE SHADOW CASTING

Figure D-3 below shows the shadow cast by the turbine and tower. The rule of thumb for the maximum distance at which the shadow will have any impact is 7 to 10 times the rotor diameter. The figure shown below denotes the ranges by two circles ranging from 371m to 530m for the larger of our selected wind turbines. Also overlaid on the two circles is the directions and intensity of the turbines shadow assuming the larger wind turbine and continuous sun throughout the year at our location. The green areas have no shadow impact while the darkest grey areas have the most. From this figure it is clear that the houses north and south of the project will not be impacted while the businesses along East Paris will only receive shadow in the late evening when they are unoccupied.

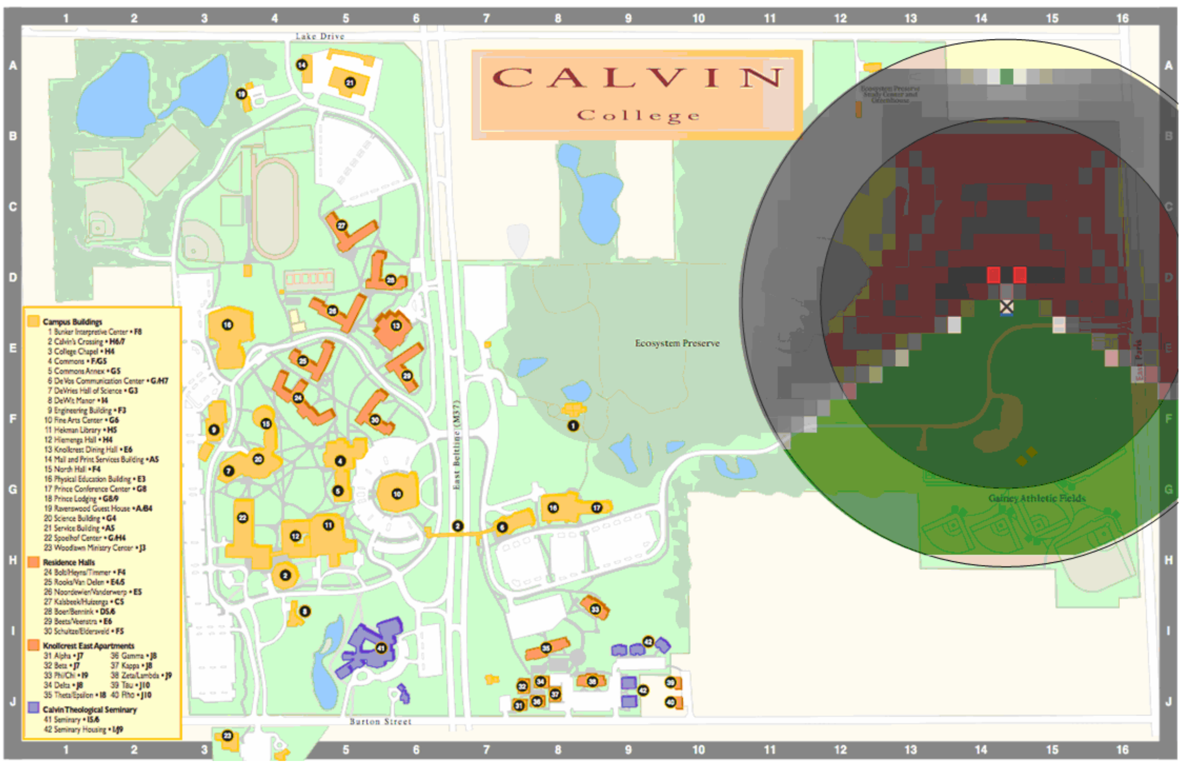


Figure D-3: Turbine Shadow casting

APPENDIX D.1.4 OFF CAMPUS LOCATIONS

The Primary off campus location considered was the Coopersville landfill shown below as "A" in Figure D-4 located at 15550 68th Ave. Coopersville, MI, 49404. This location was appealing because of its remote location. If a wind turbine would be constructed here there would be very little disagreement among the community. Other location options included sites spanning the shore of Lake Michigan. Lake front property would be desirable because of higher wind speeds but complicated due to aesthetic concerns among the community.

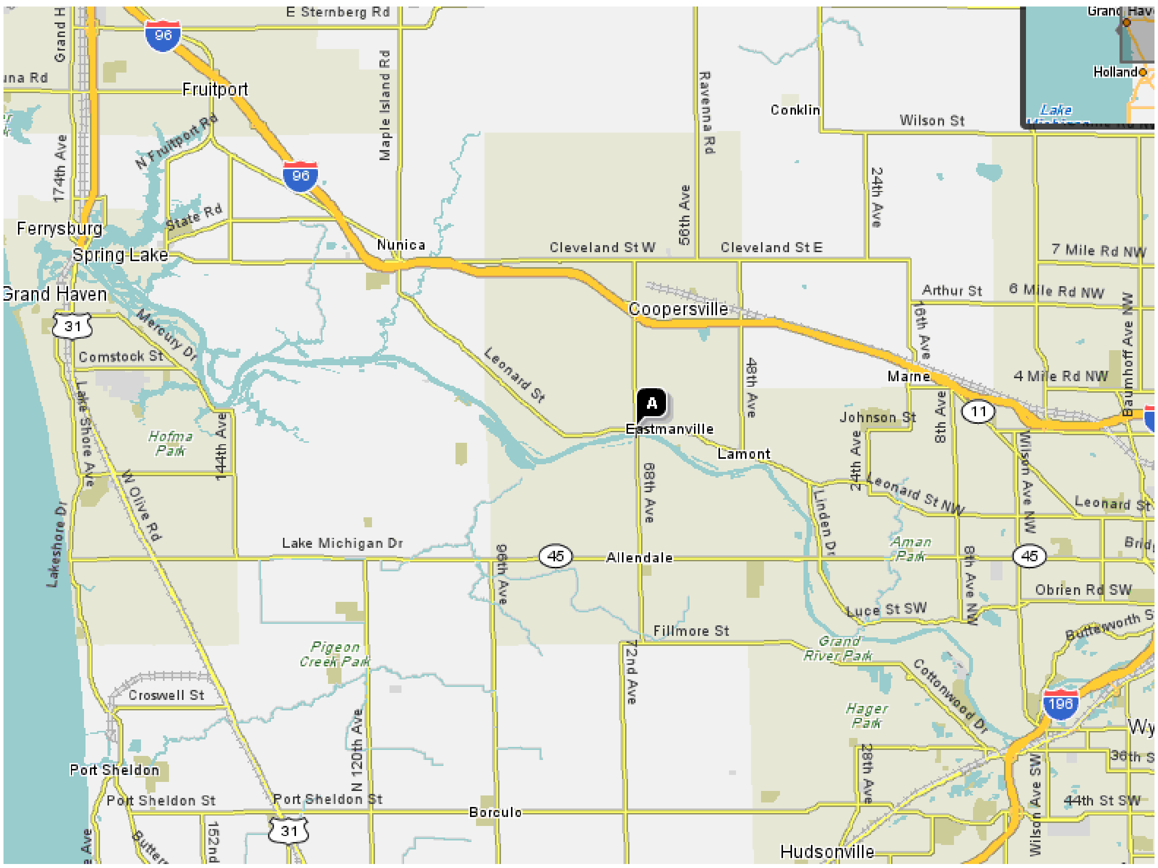


Figure D-4: Coopersville Landfill Location

APPENDIX D.2 WIND SPEED DATA

Wind speed is a critical piece of information when choosing a wind turbine because it is the main variable that determines power output. Rough data can be found from Michigan Wind Energy Resource Maps, which were created in conjunction with the National Renewable Energy Laboratory. These maps provide a range of wind speeds at a certain height. Wind shear can be estimated from the maps. Figure D-5, below, shows how the data can be extracted from the wind maps.

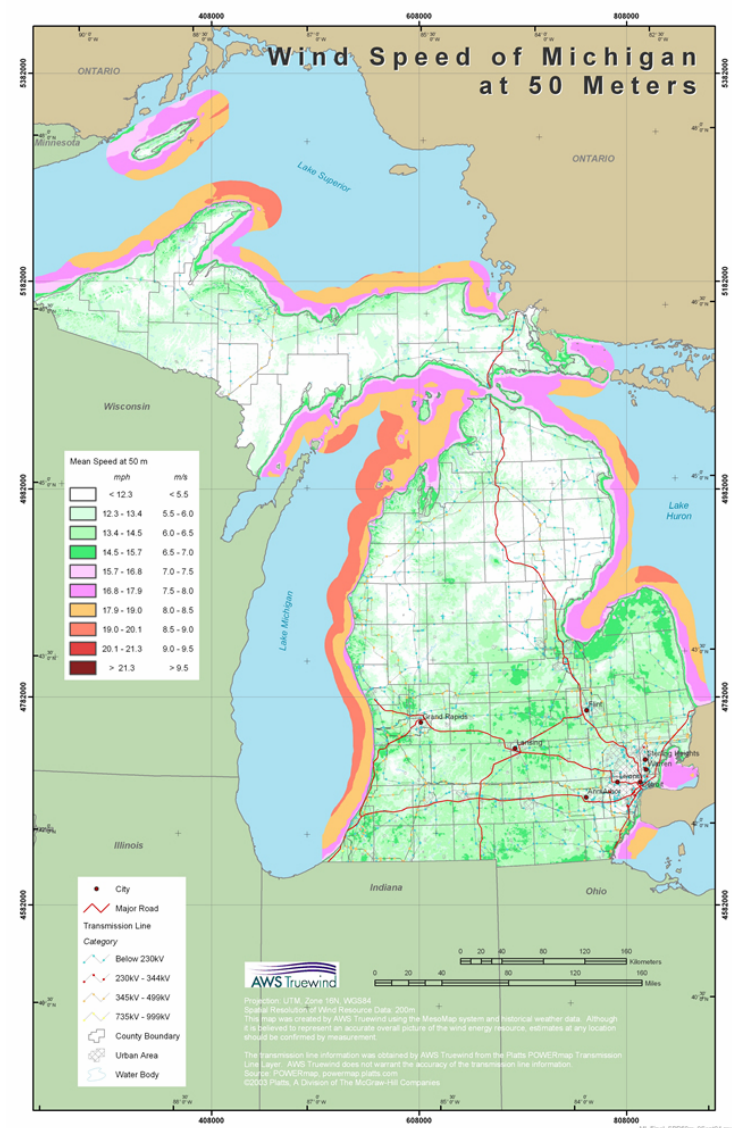


Figure D-5: Example Wind Map

The southeast region of Grand Rapids is pinpointed and the color can be matched with the color-coded legend relating to wind speed. The legend has a range of wind speeds, so the average wind speed was used. This was done at the 30, 50, 70 and 100 meter elevations, and inserted in Excel. A polynomial fit was plotted to these data points and a wind shear of 0.28 was calculated. Figure D-6 shows the excel graph made of wind speed vs height.

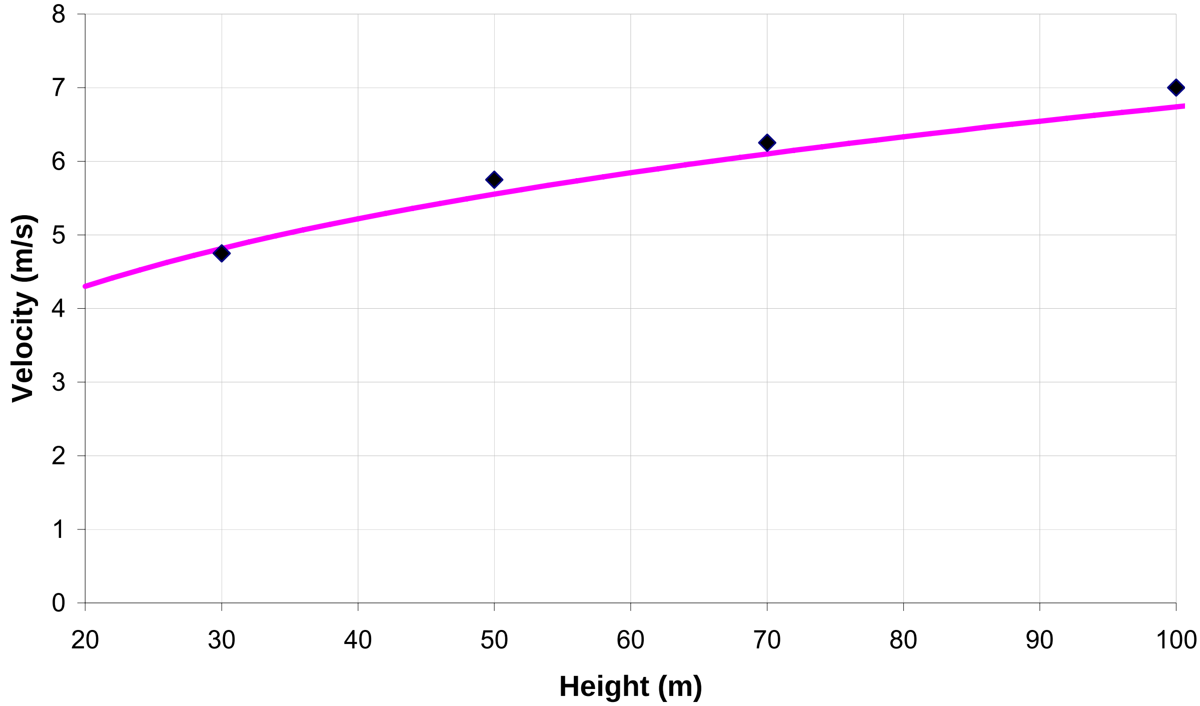


Figure D-6: Wind Speed Profile from Wind Maps

From this data wind speeds at specific heights was estimated.

According to the Ministry of Agriculture Food and Rural Affairs, no matter what measurement system you install, for a small wind turbine a minimum of one year of data should be recorded and compared with another source of wind data. Readings would be most useful if they have been taken at hub height, or the elevation at the top of the tower where the wind turbine is going to be installed.

APPENDIX D.3 MANUFACTURER SELECTION

While wind turbines have been in use for many years around the world the rapid growth in the industry and the rate of technological innovation requires the buyer carefully judge the manufactures ability both to provide a quality product and stay in business long enough to support it. Currently two basic designs dominate the large wind turbine market; the most common is the three blade upwind turbine which uses a three stage planetary and helical gearbox to feed the torque from the turbine into an induction generator. The second most common design is similar but removes the need for the gearbox by using either a multi-pole synchronous ring generator or a permanent magnet generator. Besides these two designs there are several variations worth noting that make use of an alternative design and have the potential to contribute to the market in the future.

The market for renewable energy has always been highly variable due to the dependence of renewable power projects on unreliable government incentives. This has resulted in many turbine manufacturers going out of business or merging with several other companies requiring the buyer to continuously keep up to date on such changes. A company's success or failure on technical issues is also of critical importance. A failure by the turbine to meet the predicted power curve or a technical malfunction in the modification of a turbine designed for a European grid to the North American grid is often easily hidden due to the confidentiality agreements of each project but often still become common knowledge to those who keep continuously up to date on the market.

Conventional Wind Turbine Suppliers

Ecotecnia is a manufacturer of large conventional wind turbines operating out of Spain and currently producing turbines with a capacity from 0.75-3MW. Ecotecnia is currently the second largest producer of wind turbines in Spain where lower relative inland wind speeds have forced companies to optimize their turbines for moderate to low wind speed sites. There are two reasons to consider Ecotecnia as a supplier of turbines in Michigan; first the low wind speed designs created for Spain will be beneficial for the relatively low wind speeds of Michigan. Second, the mayor of Grand Rapids has met with Ecotecnia on several occasions to discuss the construction of a manufacturing facility in Grand Rapids, currently it is believed that the introduction of a renewable portfolio standard in Michigan could result in an operational facility in as little as 1-2 years.

Fuhrlander is a rather unique German company that produces a broad range of traditional turbines from 30kW-2.5MW. Their focus appears to be on small scale projects of one or two turbines rather than large wind farms and takes an idealistic look at wind power integrating issues of community into the sustainability of their projects. They appear to offer original designs while also reselling turbines from other companies such as REPower. They appear to be one of the few companies still offering lattice towers as an option and have just recently built the largest wind turbine in the world with a hub height of 160m on a lattice tower.

Gamesa Eolica is the largest wind turbine manufacturer in Spain, one of the top three in the world and was originally formed as a subsidiary to Vestas due to the Spanish requirement that the turbines erected in Spain had to be made locally. As Gamesa began to develop lower wind speed designs and Vestas was unable to see the future market for the low speed designs lost interest and allowed Gamesa to split from them completely. Gamesa offers a range of turbines from 0.85-2MW and is the only established wind turbine manufacturer currently producing wind turbines in the United States (Pennsylvania).

General Electric is one of the fastest growing turbine manufacturers and produces 1.5-3.6MW turbines. The 1.5MW turbine is one of the most commonly used land based turbines and the 3.6MW is attempting to establish itself as the offshore standard. GE offers a solid turbine design originally created by Zond Energy systems in California, bought by Enron, then finally purchased by GE after Enron's collapse. GE wins most of the current North American projects due to the economies of scale of their company and their ability to significantly undercut the price of the competition on large projects. As of the beginning of 2006 GE would not provide a quote to any wind farm smaller than 20MW due to the large market demand.

Mitsubishi Heavy Industries has produced several conventional and gearless turbines in the range of 0.6-1MW and have relatively little experience. While they have also received contracts for several wind farms in the US it is premature to evaluate this company without more research.

Nordex is one of the older turbine manufactures from Denmark. They produce 1.3-2.5MW turbines and claim to be the first to produce both a 1MW and 2.5MW turbine (the largest in the world for several years). Nordex sells it turbines based on its relatively long experience in the industry but appears to be slipping in the current market.

Repower is a company focused on selling an integrated package in which they construct and service the turbines throughout the life of the project. They offer turbines from 1.5-5MW and also sell their turbines through contracts with a number of resellers under contract around the world.

Siemens has recently purchased a Danish company Bonus Energy, one of the oldest wind turbine companies which survived the market lows of the 80's. Bonus and now Siemens produces a solid high wind speed design from 1.3-3.6MW but has not changed the design to make use of lower wind speeds and has fallen behind in their technology.

Suzlon produces a large range of wind turbines ranging from 350kW-2MW and offers a practical design that is cost effective and reliable. Suzlon has focused its market on Asia and India in particular has had significant success. While it turbines do not integrate cutting edge technology the focus on reliability and maximized return on investment has proven very successful for use in projects in developing countries.

Vestas is currently the largest wind turbine manufacturer in the world and produces a range of turbines from 0.85-3MW. Vestas attained it position as the largest manufacturer through the acquisition of NEG Micon several years back effectively merging the two largest companies in the industry. While Vestas is a significant industry player they have had significant set backs in North America both due to technical challenges with their turbines and fierce competition from GE.

Gearless Turbine Suppliers

Enercon is a privately owned company that currently holds the largest market share in Germany and produces the only commercially proven gearless turbine design. The Enercon product range is from 330kW-6MW currently the largest turbine in the world and focuses on improvement of the entire range not just its largest. While the Enercon turbines have a greater capital cost than most turbines the improved reliability and decreased maintenance requirements more than make up for this cost. Enercon also offers numerous other design improvements which make many consider the Enercon technology the leading edge technology of the industry.

Harakosan is a Japanese company who purchased a gearless 2MW design turbine from Zephyros who originally developed the design under the Dutch company Lagerway who was forced to declare bankruptcy several years back. Lagerway produced a range of turbines including the 750kW turbine located on the lakeshore in Toronto Ontario Canada. While the Lagerway and Harakosan turbines are solid gearless designs the companies currently distributing them do not have the infrastructure to be considered reliable for a large turbine project.

Vensys is a rapidly developing company with a gearless design from 1.3-1.5MW that is just beginning to gain respect. Currently the lack of experience still makes investment in their technology somewhat of a risk and therefore often a lower price for the turbines can be attained.

Innovative Drive System Turbine Suppliers

Clipper Wind is a US company formed by the same engineers who created Zond Energy in California and did the initial design of the turbines GE is now selling. Clipper only produces a 2.5MW turbine and has only produced several so far. Clipper is the only company other than Gamesa to produce turbines in the USA (Iowa). What is unique is that the clipper turbine divides the shaft torque through a gearbox to four different small generators. This allows for the use of off the shelf generators and the changing of a generator with a small onboard crane while the other three generators continue operation. They currently offer some of the lowest costs for turbines and highest return on investment and there turbines are certified by the most reputable companies in wind power. Despite this more experience than their machines currently have is desirable.

Multibrid and **WinWinD** both use a hybrid drive train that makes use of a lower speed two stage gear box while also slowing the rotational speed of the generator using either a larger number of poles or permanent magnets. This provides a balance between the size/weight of the nacelle and reliability but currently this has only been used on several very large turbines.

DeWind/EUEnergy makes use of a fluid coupling to transfer torque from the blades to the generator and in doing so dissipates the torque spikes from sudden gusts. The benefit of this design is that the turbine can then be directly tied into the grid in a manner similar to a hydro electric turbine without the need for complex and expensive power control electronics. Third party confirmation of these claims is still not readily available despite many large projects already purchasing this technology and it is still a very new technology.

APPENDIX D.4 SELECTED TURBINES

Turbine Specifics

Enercon was selected as the turbine supplier due to both its advanced technology and appropriate business model (see appendix 3 Manufacturer Considerations for details). The Enercon turbines considered are the E33 and E53 with 330kW and 800kW nameplate capacities respectively. The E33 has a 33.4m blade diameter and 50m hub height compared to the 52.9m blade diameter and 73m hub height of the E53. More detailed product specifications can be found in the attached brochure.

Selection of Two Turbines

While a single turbine is most appropriate for two turbine options are considered to represent suitable alternatives for the site and our goals with respect to scale. The reason these options are presented in place of a single turbine recommendation is due to the close proximity of the site to a medium density residential area. While there is significant space for the turbine the high number or stake holders who may oppose the visual impact of the project may require the consideration of the smaller turbine despite the economic benefits of the larger project.

Technology Advantages

The E33 and 53 both benefit from the use of Enercon’s gearless design in which a synchronous ring generator with multiple poles is used in place of a three stage gear box to increase the effective rotational speed of the generator. The gearless design turns slower resulting in less wear and lower maintenance costs while completely eliminating the costly replacement of the gearbox common in most turbines after their fifth year of operation.

The blade design of these turbines also sets them apart by making more effective use of the entire blade length. Due to its large swept blade root these Enercon turbines are able to make use of the inner area of the rotor which most turbines ignore thereby producing more torque and energy from any given blade length and reducing the moment on the rotor from longer blades. The blade tip also is specifically curved to shed wind in a manner that minimizes aerodynamic noise.

Power production from the Enercon is also optimized through the complete electronic processing of power which allows the operator to select any power factor desirable to stabilize the local grid. Unlike other designs that draw power from the grid to start rotating at low wind speeds the lack of gearbox friction allows for a completely aerodynamic start up and also allows these turbines to start at a lower wind speed of approximately 2m/s rather than 4m/s. These advantages work together to ensure greater amounts of quality power are created than from any other turbine design.

Sales

ENERCON GmbH
Dornumer Straße 20 · 26607 Aurich · Germany
Phone +49 4941 97 60 · Fax +49 4941 97 62 99
vertrieb@enercon.de

ENERCON GmbH
Otto-Lilienthal-Straße 25 · 28199 Bremen · Germany
Phone +49 421 244 15 20 · Fax +49 421 244 15 39
sales.international@enercon.de

ENERCON GmbH · Dreekamp 5 · 26605 Aurich · Germany · Phone +49 4941 92 70 · Fax +49 4941 92 71 09 · www.enercon.de

E-33
E-44
E-48
E-53
E-70
E-82

ENERCON WIND TURBINES

PRODUCT OVERVIEW

ENERCON
ENERGY FOR THE WORLD

E33

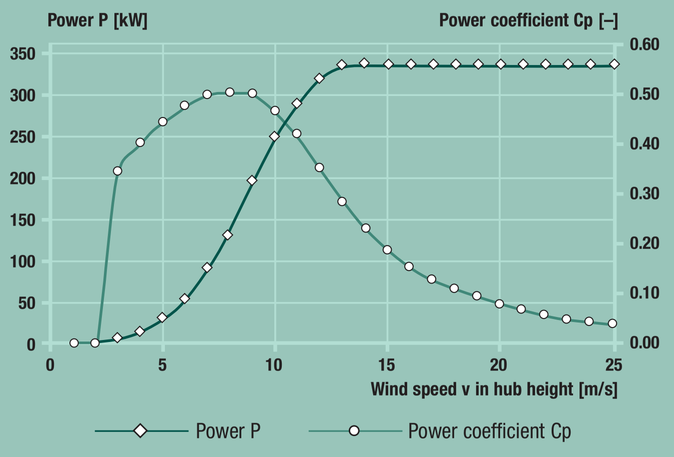
ENERCON's E-33 wind turbine makes it economically feasible to realise wind energy projects even at sites difficult to access. Their modular design allows for convenient container transport by ship and truck as well as efficient installation using one regular-sized lifting crane.

TECHNICAL DATA

Rated power:	330 kW
Rotor diameter:	33.4 m
Hub height:	44 – 50 m
Wind class (IEC):	IEC/NVN I and IEC/NVN II
Turbine concept:	Gearless, variable speed, variable pitch control
Rotor	
Type:	Upwind rotor with active pitch control
Direction of rotation:	Clockwise
Number of blades:	3
Swept area:	876 m²
Blade material:	Fibreglass (epoxy resin); integrated lightning protection
Rotational speed:	Variable, 18 – 45 rpm
Pitch control:	ENERCON blade pitch system, one independent pitching system per rotor blade with allocated emergency supply
Drive train with generator	
Hub:	Rigid
Main bearings:	Single-row cylindrical roller bearings
Generator:	ENERCON direct-drive synchronous annular generator
Grid feeding:	ENERCON converter
Braking systems:	– 3 independent blade pitch systems with emergency supply – Rotor brake – Rotor lock
Yaw control:	Active via adjustment gears, load-dependent damping
Cut-out wind speed:	28 – 34 m/s (with ENERCON storm control)
Remote monitoring:	ENERCON SCADA

Details – ENERCON Storm Control – (see last page)

CALCULATED POWER CURVE



Wind [m/s]	Power P [kW]	Power coefficient Cp [-]
1	0.0	0.00
2	0.0	0.00
3	5.0	0.35
4	13.7	0.40
5	30.0	0.45
6	55.0	0.47
7	92.0	0.50
8	138.0	0.50
9	196.0	0.50
10	250.0	0.47
11	292.8	0.41
12	320.0	0.35
13	335.0	0.28
14	335.0	0.23
15	335.0	0.18
16	335.0	0.15
17	335.0	0.13
18	335.0	0.11
19	335.0	0.09
20	335.0	0.08
21	335.0	0.07
22	335.0	0.06
23	335.0	0.05
24	335.0	0.05
25	335.0	0.04

ρ = 1.225 kg/m³

Details – ENERCON power curve – (see last page)

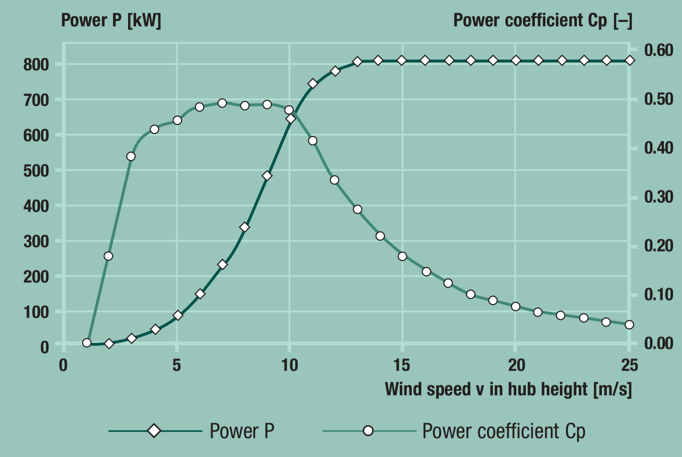
Developed for sites with medium wind speeds, the ENERCON E-53 wind turbine's expanded rotor diameter and newly designed rotor blades guarantee maximum yield even at low wind speeds.

TECHNICAL DATA

Rated power:	800 kW
Rotor diameter:	52.9 m
Hub height:	73 m
Wind class (IEC):	IEC/NVN S (v_{av} = 7.5 m/s, v_{ext} = 57 m/s)
Turbine concept:	Gearless, variable speed, variable pitch control
Rotor	
Type:	Upwind rotor with active pitch control
Direction of rotation:	Clockwise
Number of blades:	3
Swept area:	2,198 m²
Blade material:	Fibreglass (epoxy resin); integrated lightning protection
Rotational speed:	Variable, 12 – 29 rpm
Pitch control:	ENERCON blade pitch system, one independent pitching system per rotor blade with allocated emergency supply
Drive train with generator	
Hub:	Rigid
Main bearings:	Single-row cylindrical roller bearings
Generator:	ENERCON direct-drive synchronous annular generator
Grid feeding:	ENERCON converter
Braking systems:	– 3 independent blade pitch systems with emergency supply – Rotor brake – Rotor lock
Yaw control:	Active via adjustment gears, load-dependent damping
Cut-out wind speed:	28 – 34 m/s (with ENERCON storm control)
Remote monitoring:	ENERCON SCADA

Details – ENERCON Storm Control – (see last page)

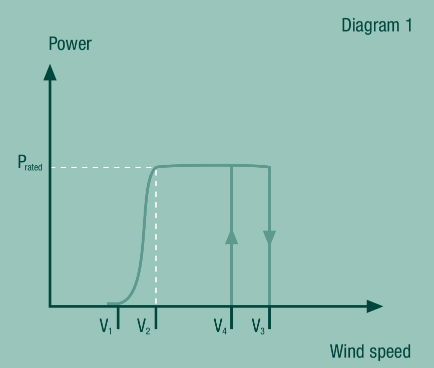
CALCULATED POWER CURVE



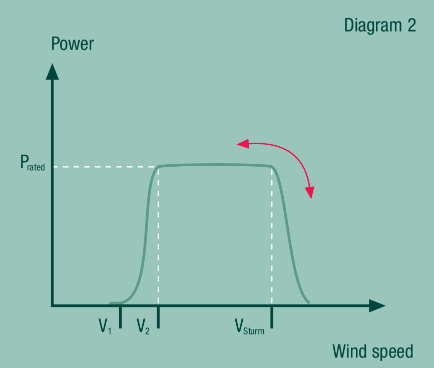
Wind [m/s]	Power P [kW]	Power coefficient Cp [-]
1	0.0	0.00
2	2.0	0.19
3	14.0	0.39
4	38.0	0.44
5	77.0	0.46
6	141.0	0.48
7	228.0	0.49
8	336.0	0.49
9	480.0	0.49
10	645.0	0.48
11	744.0	0.42
12	780.0	0.34
13	810.0	0.27
14	810.0	0.22
15	810.0	0.18
16	810.0	0.15
17	810.0	0.12
18	810.0	0.10
19	810.0	0.09
20	810.0	0.08
21	810.0	0.06
22	810.0	0.06
23	810.0	0.05
24	810.0	0.04
25	810.0	0.04

ρ = 1.225 kg/m³

Details – ENERCON power curve – (see last page)



Power curve of a wind turbine without ENERCON storm control



Power curve of a wind turbine with ENERCON storm control

ENERCON POWER CURVES

According to current standards at power curve measurement certain parameters such as turbulence intensity are not taken into consideration. The results are deviating measurements on the same type of wind turbine at different locations. Also when comparing yield using power curve measurements from different types of wind turbines, a clear picture cannot be obtained unless all measurement parameters are taking into consideration.

So in order to calculate power yield forecasts for its wind turbines, ENERCON does not use power curve measurements but calculated power curves.

These are based on the following:

- several different power curve measurements for the respective wind turbine type taken by accredited institutes with documented evidence of these measurements on the respective power curve certificates; or results from other turbine types if measurements have not yet begun or are still in progress
- average turbulence intensity 12 %
- standard air density – 1.225 kg/m³
- realistic assumptions concerning anemometer behaviour
- wind turbine operation with ENERCON's storm control feature which enables operation without shutdown at high wind speeds.

Thus the power curves for ENERCON wind turbines provide highly reliable and realistic calculations for expected energy yield according to the wind conditions at the respective site.

DESCRIPTION WIND CLASSES

IEC I V_{av} = 10 m/s
V_{ext} = 70 m/s

IEC II V_{av} = 8.5 m/s
V_{ext} = 59.5 m/s

IEC S V_{av} and V_{ext} to be determined by the manufacturer

ENERCON STORM CONTROL

ENERCON wind turbines are operated with a special storm control feature. This system enables reduced turbine operation in the event of extremely high wind speeds, and prevents the otherwise frequent shutdowns and resulting yield losses.

Power curve without ENERCON storm control

The diagram 1 shows that the wind turbine stops at a defined shutdown speed V_3. The reason being that a specified maximum wind speed has been exceeded. In the case of a wind turbine without storm control this, for example, occurs at a wind speed of 25 m/s within the 20 second mean. The wind turbine only starts up again when the average wind speed drops below the shutdown speed or a possibly even lower restart speed (V_4 in the diagram; socalled strong wind hysteresis). In gusty wind conditions there may be a longer delay, which means that considerable yield losses are incurred.

Power curve with ENERCON storm control

The power curve diagram with ENERCON storm control (diagram 2) demonstrates that the wind turbine does not shut down automatically when a certain wind speed V_{Storm} is exceeded, but merely reduces the power output by lowering the rotational speed. This is achieved by turning the rotor blades slightly out of the wind. Once the wind speed drops, the blades turn back into the wind, and the turbine immediately resumes operation at full power. Yield-reducing shutdown and start-up procedures are thus avoided.

APPENDIX D.5 TURBINE COST ANALYSIS

RETScreen Software

For the analysis of the turbines used we choose to use the RETScreen International Clean Energy Project Analysis Software Wind Energy Project Model version 3.2. This is a free software analysis tool put together in collaboration with NASA, UNEP, and the GEF for the purpose of reducing the cost associated with pre-feasibility studies for renewable energy. This software was attractive because it is able to estimate the energy production of wind turbines and the savings provided by implementing wind energy. It is also able to estimate life cycle costs and the emission reductions gained. The software includes product, cost, and climate databases which are very useful and are able to give a starting point for analysis. Furthermore there is a free detailed online user manual on how the software works.

Assumptions

Several assumptions were made when using the software:

- We choose the cost of electricity to be \$0.07/kWh since this is approximately the price Calvin currently pays for electricity and the price that a current Michigan wind project, Mackinaw Power, has required for financial viability.
- Capital Investment costs were based from the rule of \$2,000,000/MW of power generated from the turbine.
- Operations and Maintenance costs were based on \$0.01/kWh also with a \$50,000/MW rebuild cost that occurs in the 13th year, just past the project half life.
- The inflation for the project was chosen at 4%, since this number provides better insurance against rising inflation levels.
- The discount rate for money to be borrowed against for the project was set at 5%, which is the rate Calvin can borrow at
- We also chose an energy escalation rate of 3% to account for any rise in the cost of electricity over the life of the project.
- All other assumptions were made from the default values in the RETScreen software.

Results for the E33 Turbine

Project Life	25 years
Hub Wind Speed	5.8m/s
Net Present Value	-\$7760
Total Initial Costs	\$743,334
Rebuild @ yr13	\$20,000
Power Produced	670MWh
CO_2 Offset	565 metric tonnes/year

Results for the E53 Turbine

Project Life	25 years
Hub Wind Speed	6.4m/s
Net Present Value	$738,125
Total Initial Costs	$1,581,563
Rebuild @ yr13	$40,000
Power Produced	2053MWh
CO_2 Offset	1732 metric tonnes/year

Sensitivity of Results

These results are very sensitive to the inputs and assumptions stated. Since the values for wind speed are estimated from the NREL wind energy resource maps for Michigan there is a large probability that these are too general to be applicable on our site on Calvin's campus. This is important to note since power output is approximately proportional the wind velocity cubed. As an example for the E33 our models found that a difference of only 0.2m/s average wind speed would create over a 10% difference in renewable energy delivered and result in a loss or gain of approximately $100,000 NPV at conditions similar to those used in the base case.

Also the cost of electricity has a large effect on the Net Present Value of the project since a higher cost of electricity makes the project more affordable. These are the two main drivers of the affordability of the project since power output relates to electricity that does not need to be bought and depending on the turbines power output this could lead to large savings. Detailed analysis of net present value sensitivity to the avoided cost of energy, energy delivered and initial and annual costs for both projects can be found on the sensitivity and risk analysis sheets of the RETScreen models.

We performed similar sensitivity analysis using our own Wind Turbine Production Excel based model and determined it to be similar to RETScreen's results.

Wind Turbine Production

Project:	333 Wind Study	
Capacity:	**330**	kW
Hub Height:	50	m
Number of Turbines	**1**	
Total Capacity	**0.33**	MW

DISCLAIMER PLEASE READ

• This spreadsheet only compares the turbines power curves and does not take into acount transformer, line losses, wind shadow,air density or parasitic loads that change this total. This sheet was not created by a professional and should not be used in place of professional consultation or for final project decisions.

Wind Shear (Independant Calculation)		
H1	30	m
v1	4.5	m/s
H2	50	m
v2	5.5	m/s
Power Law, a	**0.393**	calculated
	0.2	applied

Measured Wind

Weibull a	6.318922215	m/s
Weibull c	2	
Height	50	m
Production	**660,740**	**kWh/yr**
Capacity Factor	**22.9%**	

Wind at Hub Height (Power Law Extrapolation)

Weibull a	6.32	m/s
Weibull c	2	
Velocity Gain	0.0%	
Energy Gain	0.0%	
Production	**660,740**	**kWh/yr**
Capacity Factor	**22.9%**	

Select Turbine From Drop Doown List Below

1

Manufacturer: Enercon

Model: E33

Power Curve Air Density 1.225 kg/m^3

Site Air Density 1.225 kg/m^3

8760 h/yr

Power Curve m/s	Power Curve kW	Mesurement Height: Wind from Weibull Distribution [%]	[h/yr]		Production [kWh/yr]	Hub Height: Wind from Weibull Distribution [%]	[h/yr]		Production [kWh/yr]
0	0	0.62%	55	-	-	0.62%	55	-	-
1	0	4.86%	425	0.05	-	4.86%	425	0.05	-
2	0	9.01%	789	0.18	-	9.01%	789	0.18	-
3	5	11.93%	1045	0.36	5,226	11.93%	1045	0.36	5,226
4	14	13.36%	1170	0.53	16,033	13.36%	1170	0.53	16,033
5	30	13.34%	1169	0.67	35,062	13.34%	1169	0.67	35,062
6	55	12.17%	1066	0.73	58,629	12.17%	1066	0.73	58,629
7	92	10.27%	899	0.72	82,733	10.27%	899	0.72	82,733
8	138	8.07%	707	0.65	97,564	8.07%	707	0.65	97,564
9	196	5.94%	521	0.53	102,020	5.94%	521	0.53	102,020
10	250	4.11%	360	0.41	90,017	4.11%	360	0.41	90,017
11	293	2.68%	235	0.29	68,689	2.68%	235	0.29	68,689
12	320	1.65%	144	0.20	46,145	1.65%	144	0.20	46,145
13	335	0.96%	84	0.12	28,054	0.96%	84	0.12	28,054
14	335	0.53%	46	0.07	15,407	0.53%	46	0.07	15,407
15	335	0.27%	24	0.04	8,009	0.27%	24	0.04	8,009
16	335	0.13%	12	0.02	3,943	0.13%	12	0.02	3,943
17	335	0.06%	5	0.01	1,839	0.06%	5	0.01	1,839
18	335	0.03%	2	0.00	814	0.03%	2	0.00	814
19	335	0.01%	1	0.00	341	0.01%	1	0.00	341
20	335	0.00%	0	0.00	136	0.00%	0	0.00	136
21	335	0.00%	0	0.00	51	0.00%	0	0.00	51
22	335	0.00%	0	0.00	18	0.00%	0	0.00	18
23	335	0.00%	0	0.00	6	0.00%	0	0.00	6
24	335	0.00%	0	0.00	2	0.00%	0	0.00	2
25	335	0.00%	0	0.00	1	0.00%	0	0.00	1
26	0	0.00%	0	0.00	-	0.00%	0	0.00	-
27	0	0.00%	0	0.00	-	0.00%	0	0.00	-
28	0	0.00%	0	0.00	-	0.00%	0	0.00	-
29	0	0.00%	0	0.00	-	0.00%	0	0.00	-
30	0	0.00%	0	0.00	-	0.00%	0	0.00	-
		1.00	8,760.00	**5.60**	660,740	1.00	8,760	5.60	660,740

SOLVE FOR BY CHANGING WEIBULL A

4.5m/s-5m/s

Simple Financial Model for Comparison

Rate (incl, incentives)	$0.07	per kWh
Discount Rate	5%	
Project Capital Cost	$ 412,500	(incl. construction,shipping…)
Annual O&M Costs	$ 5,000	p.a.
Availability	97.0%	
20-yr Sum	**$ 99,784**	
20-yr NPV	**-$ 68,708**	
IRR	**2.5%**	

Year	Costs	Revenue	Balance
1	$ 417,500	$ 44,864	-$ 372,636
2	$ 20,000	$ 44,864	$ 24,864
3	$ 20,000	$ 44,864	$ 24,864
4	$ 20,000	$ 44,864	$ 24,864
5	$ 20,000	$ 44,864	$ 24,864
6	$ 20,000	$ 44,864	$ 24,864
7	$ 20,000	$ 44,864	$ 24,864
8	$ 20,000	$ 44,864	$ 24,864
9	$ 20,000	$ 44,864	$ 24,864
10	$ 20,000	$ 44,864	$ 24,864
11	$ 20,000	$ 44,864	$ 24,864
12	$ 20,000	$ 44,864	$ 24,864
13	$ 20,000	$ 44,864	$ 24,864

manual input

output

Natural Resources Canada   Ressources naturelles Canada   Canada

RETScreen® International

Clean Energy Project Analysis Software

Wind Energy Project Model

Click Here to Start
- Description & Flow Chart
- Colour Coding
- Online Manual

Worksheets
- Energy Model
- Equipment Data
- Cost Analysis
- Greenhouse Gas Analysis
- Financial Summary

Features
- Product Data
- Weather Data
- Cost Data
- Unit Options
- Currency Options
- CDM / JI Project Analysis
- Sensitivity Analysis

Clean Energy Decision Support Centre
www.retscreen.net

Training & Support
Internet Forums
Marketplace
Case Studies
e-Textbook

Partners

NASA   UNEP   GEF

RETScreen® Energy Model - Wind Energy Project

Training & Support

Units: Metric

Site Conditions		Estimate	Notes/Range
Project name		**Enercon E33**	See Online Manual
Project location		**Calvin College**	
Wind data source		Wind speed	
Nearest location for weather data		Grand Rapids, MI	See Weather Database
Annual average wind speed	m/s	4.4	
Height of wind measurement	m	6.1	3.0 to 100.0 m
Wind shear exponent	-	0.13	0.10 to 0.40
Wind speed at 10 m	m/s	4.7	
Average atmospheric pressure	kPa	98.8	60.0 to 103.0 kPa
Annual average temperature	°C	9	-20 to 30 °C

System Characteristics		Estimate	Notes/Range
Grid type	-	Central-grid	
Wind turbine rated power	kW	330	Complete Equipment Data sheet
Number of turbines	-	1	
Wind plant capacity	kW	330	
Hub height	m	50.0	6.0 to 100.0 m
Wind speed at hub height	m/s	5.8	
Wind power density at hub height	W/m²	227	
Array losses	%	0%	0% to 20%
Airfoil soiling and/or icing losses	%	2%	1% to 10%
Other downtime losses	%	2%	2% to 7%
Miscellaneous losses	%	2%	2% to 6%

Annual Energy Production		Estimate Per Turbine	Estimate Total	Notes/Range
Wind plant capacity	kW	330	330	
	MW	0.330	0.330	
Unadjusted energy production	MWh	713	713	
Pressure adjustment coefficient	-	0.98	0.98	0.59 to 1.02
Temperature adjustment coefficient	-	1.02	1.02	0.98 to 1.15
Gross energy production	MWh	712	712	
Losses coefficient	-	0.94	0.94	0.75 to 1.00
Specific yield	kWh/m²	765	765	150 to 1,500 kWh/m²
Wind plant capacity factor	%	23%	23%	20% to 40%
Renewable energy delivered	MWh	670	**670**	
	GJ	2,413	2,413	

Complete Cost Analysis sheet

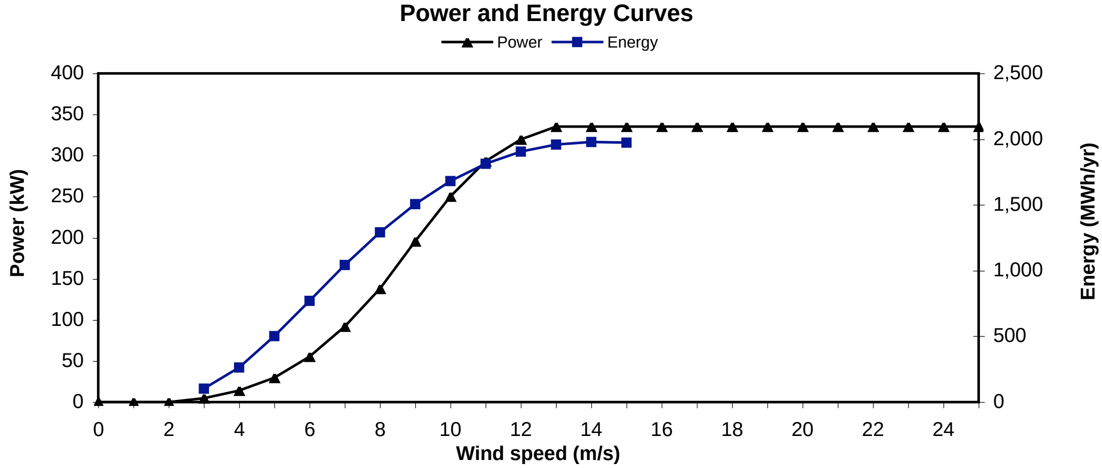
RETScreen® Equipment Data - Wind Energy Project

Wind Turbine Characteristics		Estimate	Notes/Range
Wind turbine rated power	kW	330	See Product Database
Hub height	m	50.0	6.0 to 100.0 m
Rotor diameter	m	33	7 to 80 m
Swept area	m²	876	35 to 5,027 m²
Wind turbine manufacturer		Enercon	
Wind turbine model		Enercon - 33	
Energy curve data source	-	Standard	Rayleigh wind distribution
Shape factor	-	2.0	

Wind Turbine Production Data

Wind speed (m/s)	Power curve data (kW)	Energy curve data (MWh/yr)
0	0.0	-
1	0.0	-
2	0.0	-
3	5.0	103.8
4	13.7	265.0
5	30.0	499.6
6	55.0	771.2
7	92.0	1,042.8
8	138.0	1,291.5
9	196.0	1,506.0
10	250.0	1,680.8
11	292.8	1,813.7
12	320.0	1,905.6
13	335.0	1,959.7
14	335.0	1,980.9
15	335.0	1,975.1
16	335.0	-
17	335.0	-
18	335.0	-
19	335.0	-
20	335.0	-
21	335.0	-
22	335.0	-
23	335.0	-
24	335.0	-
25	335.0	-

Power and Energy Curves



Return to
Energy Model sheet

RETScreen® Cost Analysis - Wind Energy Project

Type of analysis:	Pre-feasibility	Currency:	$	Cost references:	None

Initial Costs (Credits)	Unit	Quantity	Unit Cost	Amount	Relative Costs	Quantity Range	Unit Cost Range
Feasibility Study							
Feasibility study	Cost	1	$ -	$ -		-	-
Sub-total:				**$ -**	0.0%		
Development							
Development	Cost	1	$ -	$ -		-	-
Sub-total:				**$ -**	0.0%		
Engineering							
Engineering	Cost	1	$ -	$ -		-	-
Sub-total:				**$ -**	0.0%		
Energy Equipment							
Wind turbine(s)	kW	330	$ 1,250	$ 412,500		-	-
Spare parts	%	20.0%	$ 412,500	$ 82,500		-	-
Transportation	turbine	1	$ 20,000	$ 20,000		-	-
Other - Energy equipment	Cost	0	$ -	$ -		-	-
Sub-total:				**$ 515,000**	69.3%		
Balance of Plant							
Balance of plant	Cost	1	$ 190,000	$ 190,000		-	-
Sub-total:				**$ 190,000**	25.6%		
Miscellaneous							
Contingencies	%	5%	$ 705,000	$ 35,250		-	-
Interest during construction	5.0%	2 month(s)	$ 740,250	$ 3,084		-	-
Sub-total:				**$ 38,334**	5.2%		
Initial Costs - Total				**$ 743,334**	100.0%		

Annual Costs (Credits)	Unit	Quantity	Unit Cost	Amount	Relative Costs	Quantity Range	Unit Cost Range
O&M							
O&M	Cost	695,000	$ 0	$ 6,950		-	-
Contingencies	%	10%	$ 6,950	$ 695		-	-
Annual Costs - Total				**$ 7,645**	100.0%		

Periodic Costs (Credits)		Period	Unit Cost	Amount	Interval Range	Unit Cost Range
Complete Rebuild	Cost	13 yr	$ 20,000	**$ 20,000**	-	-
				$ -	-	-
				$ -	-	-
End of project life	Credit	-	$ -	**$ -**		*Go to GHG Analysis sheet*

Version 3.2

NRCan/CETC - Varennes

RETScreen® Greenhouse Gas (GHG) Emission Reduction Analysis - Wind Energy Project

Use GHG analysis sheet?	Yes	Type of analysis:	Standard
Potential CDM project?	No		

Background Information

Project Information

Project name	Enercon E33	Project capacity	0.33 MW	**Global Warming Potential of GHG**			
				21	tonnes CO_2 =	1 tonne CH_4	(IPCC 1996)
Project location	Calvin College	Grid type	Central-grid	310	tonnes CO_2 =	1 tonne N_2O	(IPCC 1996)

Base Case Electricity System (Baseline)

Fuel type	Fuel mix (%)	CO_2 emission factor (kg/GJ)	CH_4 emission factor (kg/GJ)	N_2O emission factor (kg/GJ)	Fuel conversion efficiency (%)	T & D losses (%)	GHG emission factor (t_{CO2}/MWh)
Coal	77.7%	94.6	0.0020	0.0030	35.0%	12.0%	1.117
Nuclear	18.6%	0.0	0.0000	0.0000	30.0%	12.0%	0.000
Natural gas	2.2%	56.1	0.0030	0.0010	45.0%	12.0%	0.513
#6 oil	0.8%	77.4	0.0030	0.0020	30.0%	12.0%	1.065
Biomass	0.6%	0.0	0.0320	0.0040	25.0%	12.0%	0.031
Large hydro	0.1%	0.0	0.0000	0.0000	100.0%	12.0%	0.000
Electricity mix	100%	244.1	0.0062	0.0078		12.0%	0.888

Does baseline change during project life? No

Proposed Case Electricity System (Wind Energy Project)

Fuel type	Fuel mix (%)	CO_2 emission factor (kg/GJ)	CH_4 emission factor (kg/GJ)	N_2O emission factor (kg/GJ)	Fuel conversion efficiency (%)	T & D losses (%)	GHG emission factor (t_{CO2}/MWh)
Electricity system							
Wind	100.0%	0.0	0.0000	0.0000	100.0%	5.0%	0.000

GHG Emission Reduction Summary

	Base case GHG emission factor (tCO2/MWh)	Proposed case GHG emission factor (tCO2/MWh)	End-use annual energy delivered (MWh)	Gross annual GHG emission reduction (t_{CO2})	GHG credits transaction fee (%)	Net annual GHG emission reduction (t_{CO2})
Electricity system	0.888	0.000	637	565	0.0%	**565**

Complete Financial Summary sheet

Version 3.2

UNEP/DTIE and NRCan/CETC - Varennes

RETScreen® Financial Summary - Wind Energy Project

Annual Energy Balance

Project name		Enercon E33			
Project location		Calvin College			
Renewable energy delivered	MWh	670	Net GHG reduction	t_{CO2}/yr	565
Excess RE available	MWh	-			
Firm RE capacity	kW	-			
Grid type		Central-grid	Net GHG emission reduction - 25 yrs	t_{CO2}	14,137

Financial Parameters

Avoided cost of energy	$/kWh	0.0700	Debt ratio	%	0.0%
RE production credit	$/kWh	-			
GHG emission reduction credit	$/$t_{CO2}$	-	Income tax analysis?	yes/no	No
Energy cost escalation rate	%	3.0%			
Inflation	%	4.0%			
Discount rate	%	5.0%			
Project life	yr	25			

Project Costs and Savings

Initial Costs				**Annual Costs and Debt**		
Feasibility study	0.0%	$	-	O&M	$	7,645
Development	0.0%	$	-			
Engineering	0.0%	$	-			
Energy equipment	69.3%	$	515,000	**Annual Costs and Debt - Total**	**$**	**7,645**
Balance of plant	25.6%	$	190,000			
Miscellaneous	5.2%	$	38,334	**Annual Savings or Income**		
Initial Costs - Total	**100.0%**	**$**	**743,334**	Energy savings/income	$	46,924
				Capacity savings/income	$	-
Incentives/Grants		$	-			
				Annual Savings - Total	**$**	**46,924**
Periodic Costs (Credits)						
Complete Rebuild		$	20,000	Schedule yr # 13		
		$	-			
		$	-			
End of project life - Credit		$	-			

Financial Feasibility

			Calculate energy production cost?	yes/no	No
Pre-tax IRR and ROI	%	4.9%			
After-tax IRR and ROI	%	4.9%	Calculate GHG reduction cost?	yes/no	No
Simple Payback	yr	18.9			
Year-to-positive cash flow	yr	15.6	Project equity	$	743,334
Net Present Value - NPV	$	(7,760)			
Annual Life Cycle Savings	$	(551)			
Benefit-Cost (B-C) ratio	-	0.99			

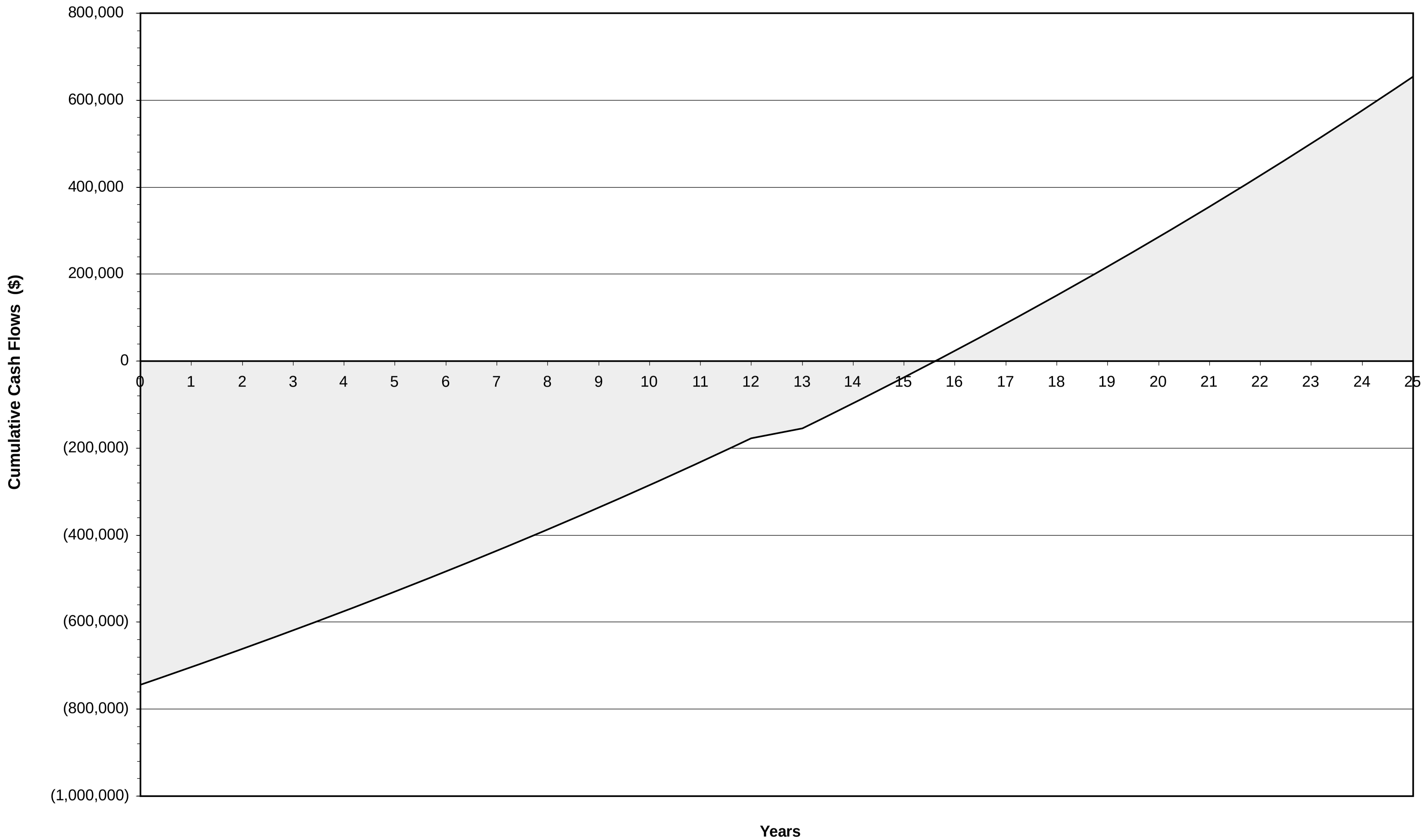
Yearly Cash Flows

Year #	Pre-tax $	After-tax $	Cumulative $
0	(743,334)	(743,334)	(743,334)
1	40,380	40,380	(702,954)
2	41,512	41,512	(661,442)
3	42,675	42,675	(618,767)
4	43,869	43,869	(574,897)
5	45,096	45,096	(529,801)
6	46,356	46,356	(483,446)
7	47,650	47,650	(435,796)
8	48,979	48,979	(386,817)
9	50,343	50,343	(336,474)
10	51,745	51,745	(284,729)
11	53,184	53,184	(231,545)
12	54,662	54,662	(176,883)
13	22,878	22,878	(154,006)
14	57,737	57,737	(96,268)
15	59,337	59,337	(36,931)
16	60,980	60,980	24,048
17	62,666	62,666	86,714
18	64,397	64,397	151,111
19	66,174	66,174	217,285
20	67,998	67,998	285,283
21	69,870	69,870	355,153
22	71,792	71,792	426,945
23	73,765	73,765	500,710
24	75,789	75,789	576,499
25	77,867	77,867	654,367

Cumulative Cash Flows Graph

Wind Energy Project Cumulative Cash Flows
Enercon E33, Calvin College

Renewable energy delivered (MWh/yr): 670 | **Total Initial Costs: $ 743,334** | **Net average GHG reduction (t_{CO2}/yr): 565**



IRR and ROI: 4.9% | **Year-to-positive cash flow: 15.6 yr** | **Net Present Value: $ -7,760**

RETScreen® Sensitivity and Risk Analysis - Wind Energy Project

Use sensitivity analysis sheet?	Yes	Perform analysis on	Net Present Value - NPV
Perform risk analysis too?	Yes	Sensitivity range	20%
Project name	Enercon E33	Threshold	0 $
Project location	Calvin College		

Sensitivity Analysis for Net Present Value - NPV

RE delivered (MWh)		Avoided cost of energy ($/kWh) 0.0560 -20%	0.0630 -10%	**0.0700** 0%	0.0770 10%	0.0840 20%
536	-20%	-339,826	-266,033	-192,241	-118,448	-44,656
603	-10%	-266,033	-183,017	-100,000	-16,984	66,033
670	0%	-192,241	-100,000	**-7,760**	84,481	176,721
737	10%	-118,448	-16,984	84,481	185,945	287,410
804	20%	-44,656	66,033	176,721	287,410	398,098

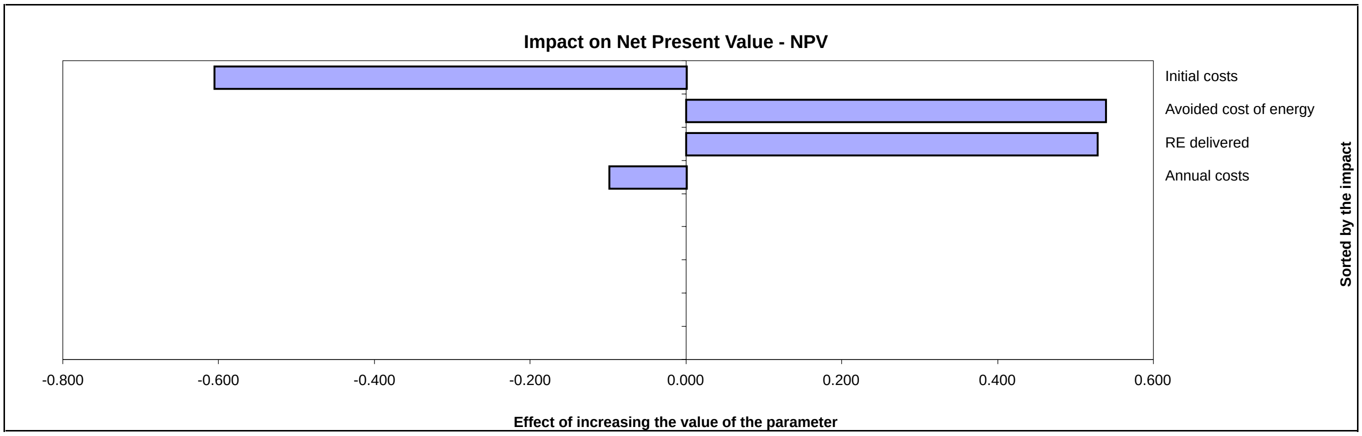
Initial costs ($)		Avoided cost of energy ($/kWh) 0.0560 -20%	0.0630 -10%	**0.0700** 0%	0.0770 10%	0.0840 20%
594,668	-20%	-43,574	48,667	140,907	233,148	325,388
669,001	-10%	-117,907	-25,667	66,574	158,814	251,055
743,334	0%	-192,241	-100,000	**-7,760**	84,481	176,721
817,668	10%	-266,574	-174,334	-82,093	10,147	102,388
892,001	20%	-340,908	-248,667	-156,427	-64,186	28,054

Annual costs ($)		Avoided cost of energy ($/kWh) 0.0560 -20%	0.0630 -10%	**0.0700** 0%	0.0770 10%	0.0840 20%
6,116	-20%	-158,407	-66,166	26,074	118,315	210,555
6,881	-10%	-175,324	-83,083	9,157	101,398	193,638
7,645	0%	-192,241	-100,000	**-7,760**	84,481	176,721
8,410	10%	-209,158	-116,917	-24,677	67,564	159,804
9,174	20%	-226,075	-133,834	-41,594	50,647	142,887

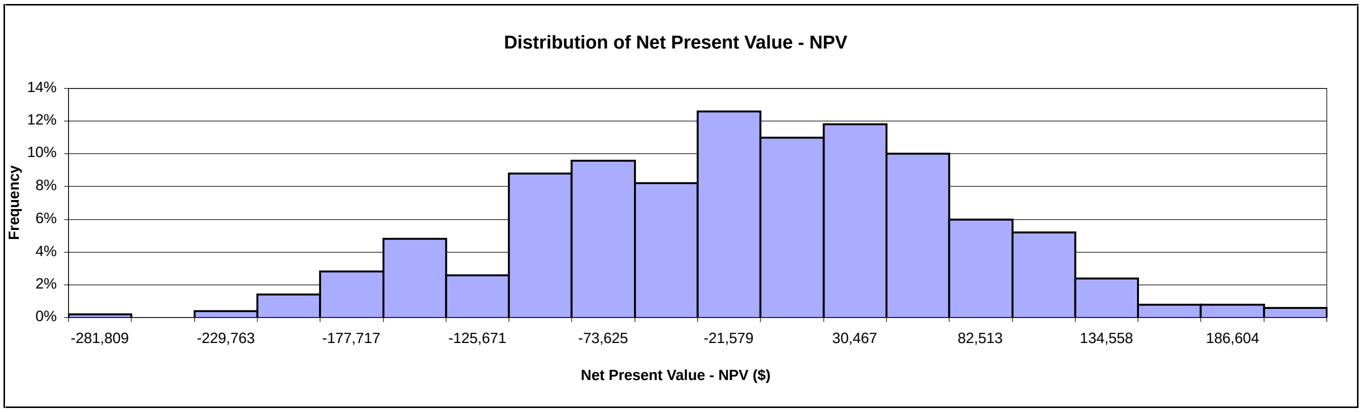
RETScreen® Sensitivity and Risk Analysis - Wind Energy Project

Risk Analysis for Net Present Value - NPV

Parameter	Unit	Value	Range (+/-)	Minimum	Maximum
Avoided cost of energy	$/kWh	0.0700	15%	0.0595	0.0805
RE delivered	MWh	670	15%	570	771
Initial costs	$	743,334	20%	594,668	892,001
Annual costs	$	7,645	15%	6,498	8,792



Median	$	-10,909
Level of risk	%	10%
Minimum within level of confidence	$	-158,252
Maximum within level of confidence	$	116,465



	Minimum	Median	Maximum	
5.0%	Level of confidence = 90%			5.0%
	$ -158,252	$ -10,909	$ 116,465	

RETScreen® Energy Model - Wind Energy Project

Training & Support

Units: Metric

Site Conditions		Estimate	Notes/Range
Project name		**E53 Option**	See Online Manual
Project location		**Grand Rapids MI**	
Wind data source		Wind speed	
Nearest location for weather data		Grand Rapids, MI	See Weather Database
Annual average wind speed	m/s	4.4	
Height of wind measurement	m	6.1	3.0 to 100.0 m
Wind shear exponent	-	0.15	0.10 to 0.40
Wind speed at 10 m	m/s	4.7	
Average atmospheric pressure	kPa	98.8	60.0 to 103.0 kPa
Annual average temperature	°C	9	-20 to 30 °C

System Characteristics		Estimate	Notes/Range
Grid type	-	Central-grid	
Wind turbine rated power	kW	800	Complete Equipment Data sheet
Number of turbines	-	1	
Wind plant capacity	kW	800	
Hub height	m	73.0	6.0 to 100.0 m
Wind speed at hub height	m/s	6.4	
Wind power density at hub height	W/m²	305	
Array losses	%	0%	0% to 20%
Airfoil soiling and/or icing losses	%	2%	1% to 10%
Other downtime losses	%	2%	2% to 7%
Miscellaneous losses	%	2%	2% to 6%

Annual Energy Production		Estimate Per Turbine	Estimate Total	Notes/Range
Wind plant capacity	kW	800	800	
	MW	0.800	0.800	
Unadjusted energy production	MWh	2,183	2,183	
Pressure adjustment coefficient	-	0.98	0.98	0.59 to 1.02
Temperature adjustment coefficient	-	1.02	1.02	0.98 to 1.15
Gross energy production	MWh	2,182	2,182	
Losses coefficient	-	0.94	0.94	0.75 to 1.00
Specific yield	kWh/m²	931	931	150 to 1,500 kWh/m²
Wind plant capacity factor	%	29%	29%	20% to 40%
Renewable energy delivered	MWh	2,053	**2,053**	
	GJ	7,392	7,392	

Complete Cost Analysis sheet

Version 3.2 NRCan/CETC - Varennes

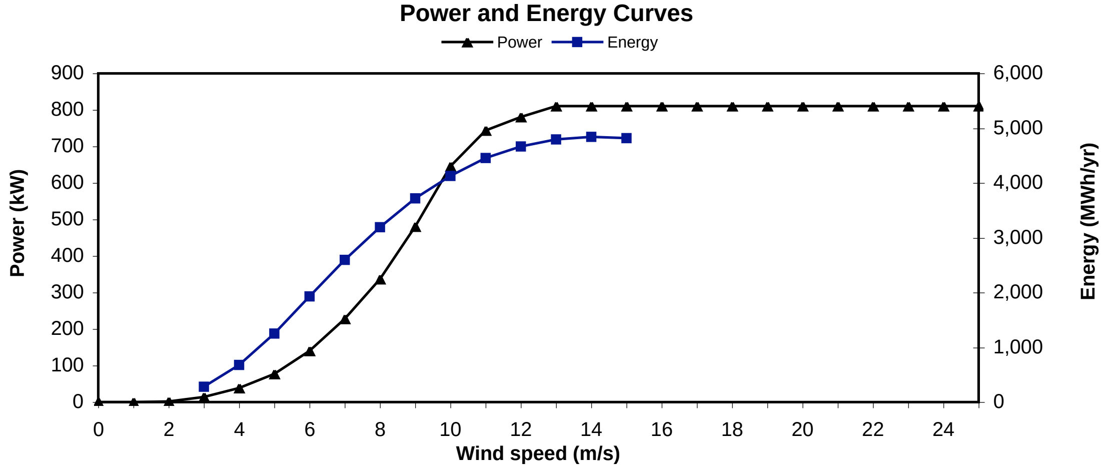
RETScreen® Equipment Data - Wind Energy Project

Wind Turbine Characteristics		Estimate	Notes/Range
Wind turbine rated power	kW	800	See Product Database
Hub height	m	73.0	6.0 to 100.0 m
Rotor diameter	m	53	7 to 80 m
Swept area	m²	2,206	35 to 5,027 m²
Wind turbine manufacturer		Enercon	
Wind turbine model		ENERCON - 53	
Energy curve data source	-	Standard	Rayleigh wind distribution
Shape factor	-	2.0	

Wind Turbine Production Data

Wind speed (m/s)	Power curve data (kW)	Energy curve data (MWh/yr)
0	0.0	-
1	0.0	-
2	2.0	-
3	14.0	274.9
4	38.0	675.4
5	77.0	1,256.3
6	141.0	1,926.4
7	228.0	2,591.8
8	336.0	3,196.6
9	480.0	3,714.5
10	645.0	4,134.0
11	744.0	4,451.2
12	780.0	4,668.5
13	810.0	4,794.4
14	810.0	4,841.0
15	810.0	4,822.6
16	810.0	-
17	810.0	-
18	810.0	-
19	810.0	-
20	810.0	-
21	810.0	-
22	810.0	-
23	810.0	-
24	810.0	-
25	810.0	-

Power and Energy Curves



Return to
Energy Model sheet

Version 3.2

11/29/06; E53 Project.xls

NRCan/CETC - Varennes

RETScreen® Cost Analysis - Wind Energy Project

Type of analysis: Pre-feasibility | Currency: $ | Cost references: None

Initial Costs (Credits)	Unit	Quantity	Unit Cost	Amount	Relative Costs	Quantity Range	Unit Cost Range
Feasibility Study							
Feasibility study	Cost	1	$ -	$ -		-	-
Sub-total:				**$ -**	0.0%		
Development							
Development	Cost	1	$ -	$ -		-	-
Sub-total:				**$ -**	0.0%		
Engineering							
Engineering	Cost	1	$ -	$ -		-	-
Sub-total:				**$ -**	0.0%		
Energy Equipment							
Wind turbine(s)	kW	800	$ 1,250	$ 1,000,000		-	-
Spare parts	%	20.0%	$ 1,000,000	$ 200,000		-	-
Transportation	turbine	1	$ 50,000	$ 50,000		-	-
Other - Energy equipment	Cost	0	$ -	$ -		-	-
Sub-total:				**$ 1,250,000**	79.0%		
Balance of Plant							
Balance of plant	Cost	1	$ 250,000	$ 250,000		-	-
Sub-total:				**$ 250,000**	15.8%		
Miscellaneous							
Contingencies	%	5%	$ 1,500,000	$ 75,000		-	-
Interest during construction	5.0%	2 month(s)	$ 1,575,000	$ 6,563		-	-
Sub-total:				**$ 81,563**	5.2%		
Initial Costs - Total				**$ 1,581,563**	100.0%		

Annual Costs (Credits)	Unit	Quantity	Unit Cost	Amount	Relative Costs	Quantity Range	Unit Cost Range
O&M							
O&M	Cost	2,126,000	$ 0	$ 21,260		-	-
Contingencies	%	0%	$ 21,260	$ -		-	-
Annual Costs - Total				**$ 21,260**	100.0%		

Periodic Costs (Credits)		Period	Unit Cost	Amount	Interval Range	Unit Cost Range
Turbine Rebuild	Cost	13 yr	$ 40,000	**$ 40,000**	-	-
				$ -	-	-
				$ -	-	-
End of project life	Credit	-	$ -	**$ -**		*Go to GHG Analysis sheet*

RETScreen® Greenhouse Gas (GHG) Emission Reduction Analysis - Wind Energy Project

Use GHG analysis sheet?	Yes	Type of analysis:	Standard
Potential CDM project?	No		

Background Information

Project Information

Project name	E53 Option	Project capacity	0.80 MW	
Project location	Grand Rapids MI	Grid type	Central-grid	

Global Warming Potential of GHG

21	tonnes CO_2 =	1 tonne CH_4	(IPCC 1996)
310	tonnes CO_2 =	1 tonne N_2O	(IPCC 1996)

Base Case Electricity System (Baseline)

Fuel type	Fuel mix (%)	CO_2 emission factor (kg/GJ)	CH_4 emission factor (kg/GJ)	N_2O emission factor (kg/GJ)	Fuel conversion efficiency (%)	T & D losses (%)	GHG emission factor (t_{CO2}/MWh)
Coal	77.7%	94.6	0.0020	0.0030	35.0%	12.0%	1.117
Large hydro	0.1%	0.0	0.0000	0.0000	100.0%	12.0%	0.000
Natural gas	2.2%	56.1	0.0030	0.0010	45.0%	12.0%	0.513
Nuclear	18.6%	0.0	0.0000	0.0000	30.0%	12.0%	0.000
#6 oil	0.8%	77.4	0.0030	0.0020	30.0%	12.0%	1.065
Biomass	0.6%	0.0	0.0320	0.0040	25.0%	12.0%	0.031
Electricity mix	100%	244.1	0.0062	0.0078		12.0%	0.888

Does baseline change during project life? No

Proposed Case Electricity System (Wind Energy Project)

Fuel type	Fuel mix (%)	CO_2 emission factor (kg/GJ)	CH_4 emission factor (kg/GJ)	N_2O emission factor (kg/GJ)	Fuel conversion efficiency (%)	T & D losses (%)	GHG emission factor (t_{CO2}/MWh)
Electricity system							
Wind	100.0%	0.0	0.0000	0.0000	100.0%	5.0%	0.000

GHG Emission Reduction Summary

	Base case GHG emission factor (tCO2/MWh)	Proposed case GHG emission factor (tCO2/MWh)	End-use annual energy delivered (MWh)	Gross annual GHG emission reduction (t_{CO2})	GHG credits transaction fee (%)	Net annual GHG emission reduction (t_{CO2})
Electricity system	0.888	0.000	1,951	1,732	0.0%	**1,732**

Complete Financial Summary sheet

Version 3.2

UNEP/DTIE and NRCan/CETC - Varennes

RETScreen® Financial Summary - Wind Energy Project

Annual Energy Balance

Project name		E53 Option			
Project location		Grand Rapids MI			
Renewable energy delivered	MWh	2,053	Net GHG reduction	t_{CO2}/yr	1,732
Excess RE available	MWh	-			
Firm RE capacity	kW	-			
Grid type		Central-grid	Net GHG emission reduction - 25 yrs	t_{CO2}	43,303

Financial Parameters

Avoided cost of energy	$/kWh	0.0700	Debt ratio	%	0.0%
RE production credit	$/kWh	-			
GHG emission reduction credit	$/$t_{CO2}$	-	Income tax analysis?	yes/no	No
Energy cost escalation rate	%	3.0%			
Inflation	%	4.0%			
Discount rate	%	5.0%			
Project life	yr	25			

Project Costs and Savings

Initial Costs				**Annual Costs and Debt**		
Feasibility study	0.0%	$	-	O&M	$	21,260
Development	0.0%	$	-			
Engineering	0.0%	$	-			
Energy equipment	79.0%	$	1,250,000	**Annual Costs and Debt - Total**	**$**	**21,260**
Balance of plant	15.8%	$	250,000			
Miscellaneous	5.2%	$	81,563	**Annual Savings or Income**		
Initial Costs - Total	100.0%	**$**	**1,581,563**	Energy savings/income	$	143,733
				Capacity savings/income	$	-
Incentives/Grants		$	-			
				Annual Savings - Total	**$**	**143,733**
Periodic Costs (Credits)						
Turbine Rebuild		$	40,000	Schedule yr # 13		
		$	-			
		$	-			
End of project life - Credit		$	-			

Financial Feasibility

			Calculate energy production cost?	yes/no	No
Pre-tax IRR and ROI	%	8.7%			
After-tax IRR and ROI	%	8.7%	Calculate GHG reduction cost?	yes/no	No
Simple Payback	yr	12.9			
Year-to-positive cash flow	yr	10.9	Project equity	$	1,581,563
Net Present Value - NPV	$	738,125			
Annual Life Cycle Savings	$	52,372			
Benefit-Cost (B-C) ratio	-	1.47			

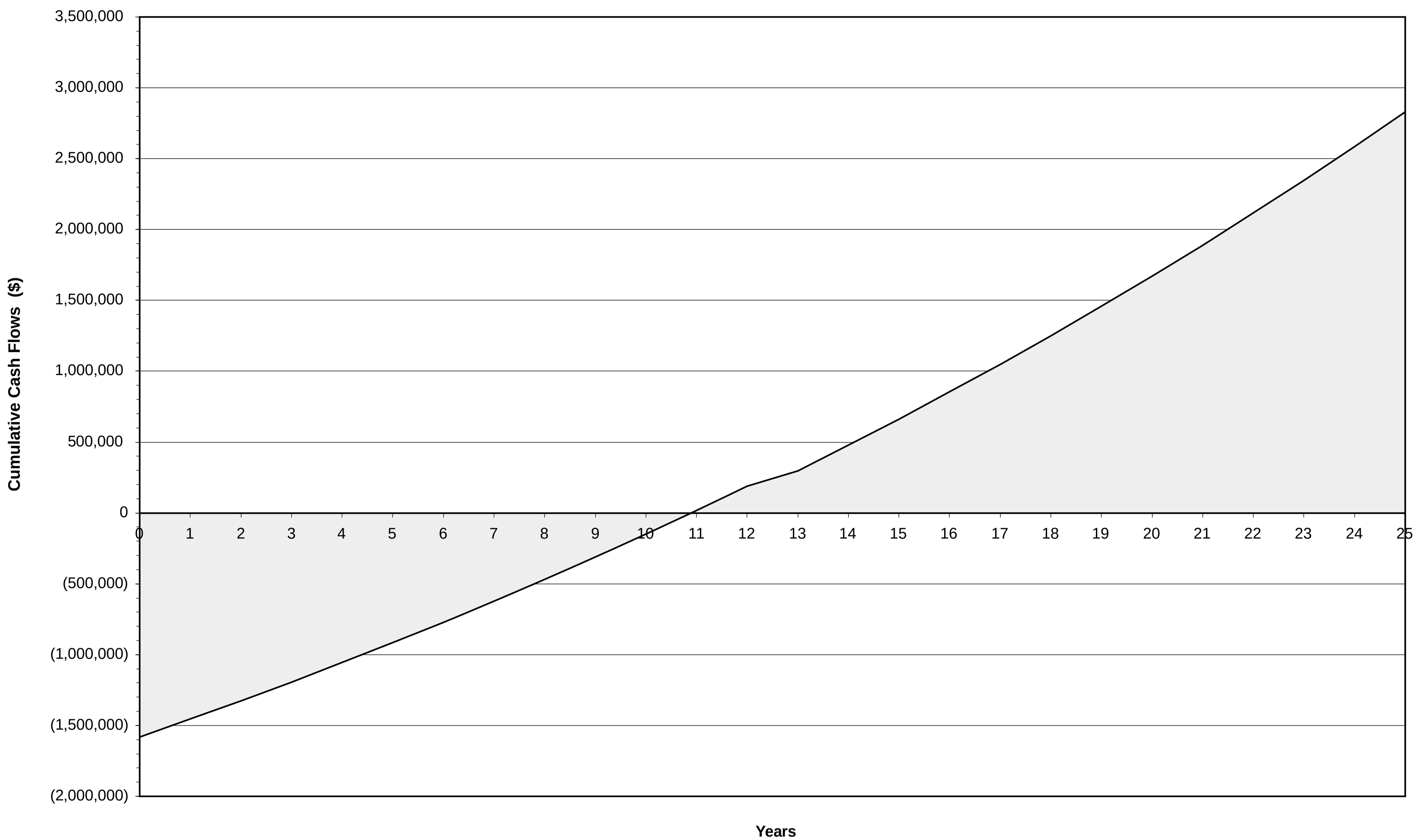
Yearly Cash Flows

Year #	Pre-tax $	After-tax $	Cumulative $
0	(1,581,563)	(1,581,563)	(1,581,563)
1	125,935	125,935	(1,455,628)
2	129,492	129,492	(1,326,136)
3	133,147	133,147	(1,192,989)
4	136,902	136,902	(1,056,088)
5	140,760	140,760	(915,327)
6	144,724	144,724	(770,603)
7	148,797	148,797	(621,806)
8	152,981	152,981	(468,825)
9	157,280	157,280	(311,545)
10	161,695	161,695	(149,850)
11	166,232	166,232	16,382
12	170,891	170,891	187,273
13	109,075	109,075	296,347
14	180,594	180,594	476,941
15	185,644	185,644	662,585
16	190,830	190,830	853,415
17	196,157	196,157	1,049,572
18	201,627	201,627	1,251,199
19	207,245	207,245	1,458,444
20	213,015	213,015	1,671,459
21	218,939	218,939	1,890,399
22	225,023	225,023	2,115,422
23	231,270	231,270	2,346,692
24	237,684	237,684	2,584,376
25	244,270	244,270	2,828,646

Cumulative Cash Flows Graph

Wind Energy Project Cumulative Cash Flows
E53 Option, Grand Rapids MI

Renewable energy delivered (MWh/yr): 2,053 | **Total Initial Costs: $ 1,581,563** | **Net average GHG reduction (t_{CO2}/yr): 1,732**



IRR and ROI: 8.7% | **Year-to-positive cash flow: 10.9 yr** | **Net Present Value: $ 738,125**

RETScreen® Sensitivity and Risk Analysis - Wind Energy Project

Use sensitivity analysis sheet?	Yes	Perform analysis on	Net Present Value - NPV	
Perform risk analysis too?	Yes	Sensitivity range	20%	
Project name	E53 Option	Threshold	0	$
Project location	Grand Rapids MI			

Click here to Calculate Sensitivity Analysis

Sensitivity Analysis for Net Present Value - NPV

RE delivered (MWh)		**Avoided cost of energy ($/kWh)** 0.0560 -20%	0.0630 -10%	**0.0700** 0%	0.0770 10%	0.0840 20%
1,643	-20%	-279,038	-53,002	173,034	399,071	625,107
1,848	-10%	-53,002	201,289	455,580	709,871	964,162
2,053	0%	173,034	455,580	**738,125**	1,020,671	1,303,216
2,259	10%	399,071	709,871	1,020,671	1,331,471	1,642,271
2,464	20%	625,107	964,162	1,303,216	1,642,271	1,981,325

Initial costs ($)		**Avoided cost of energy ($/kWh)** 0.0560 -20%	0.0630 -10%	**0.0700** 0%	0.0770 10%	0.0840 20%
1,265,250	-20%	489,347	771,892	1,054,438	1,336,983	1,619,529
1,423,406	-10%	331,191	613,736	896,282	1,178,827	1,461,372
1,581,563	0%	173,034	455,580	**738,125**	1,020,671	1,303,216
1,739,719	10%	14,878	297,424	579,969	862,514	1,145,060
1,897,875	20%	-143,278	139,267	421,813	704,358	986,904

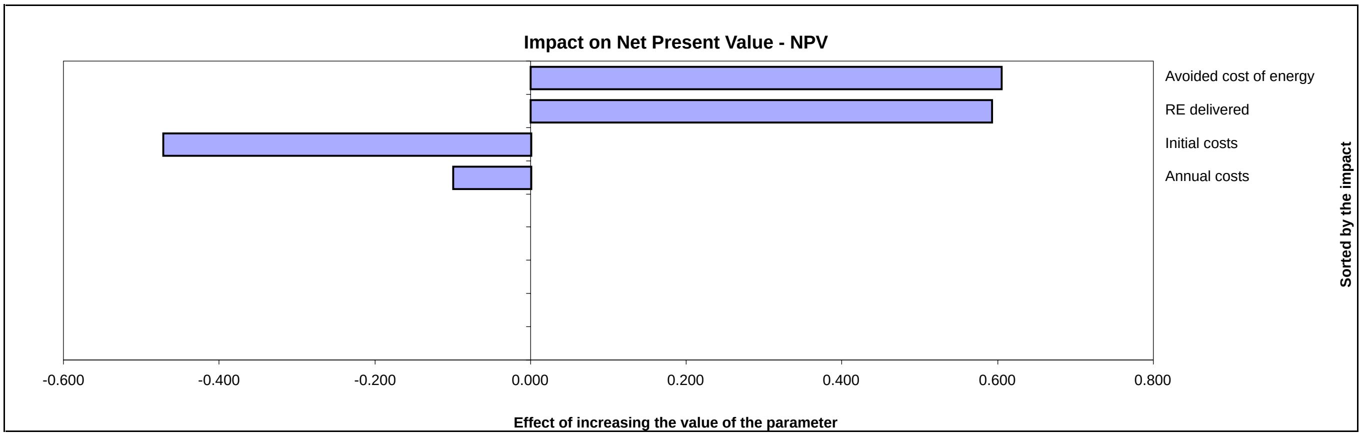
Annual costs ($)		**Avoided cost of energy ($/kWh)** 0.0560 -20%	0.0630 -10%	**0.0700** 0%	0.0770 10%	0.0840 20%
17,008	-20%	267,124	549,669	832,214	1,114,760	1,397,305
19,134	-10%	220,079	502,624	785,170	1,067,715	1,350,261
21,260	0%	173,034	455,580	**738,125**	1,020,671	1,303,216
23,386	10%	125,990	408,535	691,081	973,626	1,256,172
25,512	20%	78,945	361,491	644,036	926,582	1,209,127

RETScreen® Sensitivity and Risk Analysis - Wind Energy Project

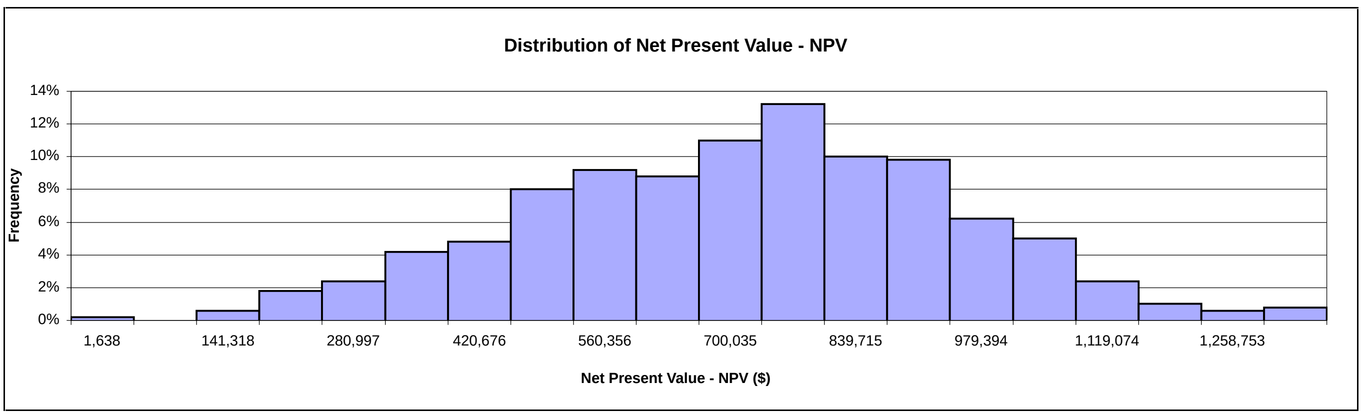
Risk Analysis for Net Present Value - NPV

Parameter	Unit	Value	Range (+/-)	Minimum	Maximum
Avoided cost of energy	$/kWh	0.0700	15%	0.0595	0.0805
RE delivered	MWh	2,053	15%	1,745	2,361
Initial costs	$	1,581,563	20%	1,265,250	1,897,875
Annual costs	$	21,260	15%	18,071	24,449

Click here to Calculate Risk Analysis



Median	$	729,963
Level of risk	%	10%
Minimum within level of confidence	$	320,623
Maximum within level of confidence	$	1,081,304



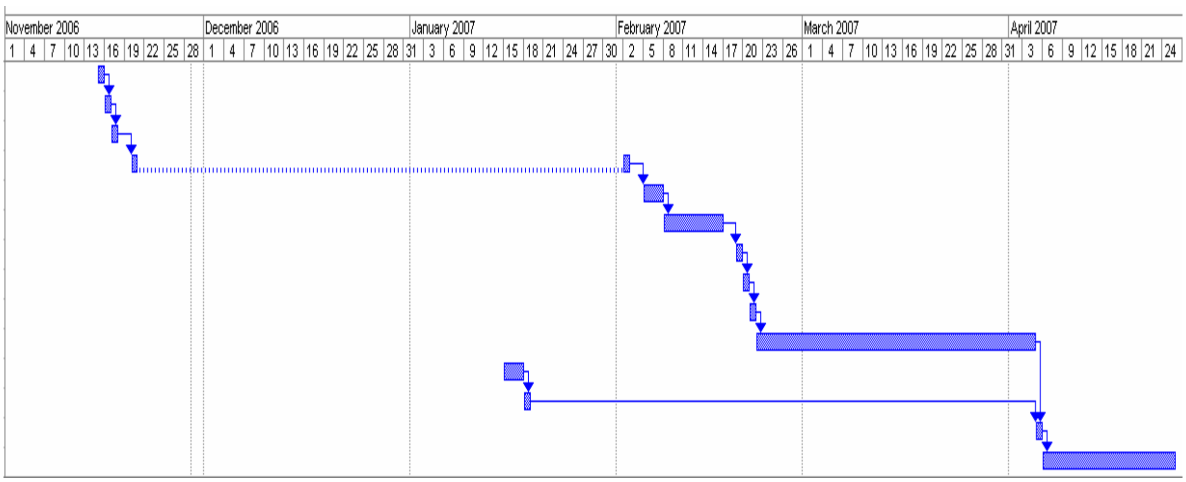
	Minimum	Median	Maximum	
5.0%		Level of confidence = 90%		5.0%
	$ 320,623	**$ 729,963**	**$ 1,081,304**	

APPENDIX D.6 CONSTRUCTION

Construction of the wind turbine will take 5 months and ten days. The construction starts with the removal and clearing of the site to the raising of the tower and turbine. A theoretical schedule of construction is shown in Table D-1.

Table D-1: Construction Schedule

Task Name	Duration	Start	Finish
Clear and grub	1 day	11/15/2006	11/15/2006
Excavation	1 day	11/16/2006	11/16/2006
Foundation Electrical	1 day	11/17/2006	11/17/2006
Lay mud slab	2 days	11/20/2006	2/2/2007
Cure mud slab	3 days	2/5/2007	2/7/2007
Lay Rebar	7 days	2/8/2007	2/16/2007
Pour Foundation	1 day	2/19/2007	2/19/2007
Strip Foundation	1 day	2/20/2007	2/20/2007
Backfill and Compact	1 day	2/21/2007	2/21/2007
Set Concrete	30 days	2/22/2007	4/4/2007
Crane pad + laydown area	3 days	1/15/2007	1/17/2007
Crane Assembly	1 day	1/18/2007	1/18/2007
Turbine Erection	1 day	4/5/2007	4/5/2007
Turbine Commisioning	14 days	4/6/2007	4/25/2007



APPENDIX D.7 FUTURE GOALS AND MILESTONES

While the long term team's analysis and conclusions are complete, there is still much to be done before Calvin College can begin construction of a wind turbine. The most important of these milestones is collecting wind data for the proposed location. Taking data at the heights of the two proposed turbines and acquiring an accurate picture of wind shear would be very useful resources for more accurate financial calculations.

In addition, Calvin College should begin promoting incentives for renewable energy in Michigan. As it stands there are little or no rewards for employing the use of renewable energy in the area. As a Christian institution Calvin is in a position to help pave the way for renewable energy in the area. Calvin can promote stewardship of our resources by promoting renewable energy.

Next, the project must be presented to the all of those who have a stake in the project. This includes the Calvin staff and faculty, current Calvin students, the community, and many others. The project should be presented in a transparent form so as to promote honest and open communication with the stakeholders, and the concerns of the stakeholders should be taken seriously when considering this project.

After the stakeholder concerns have been addressed, zoning restrictions need to be considered. Since there is no particular zoning for wind farms, variances will have to be filled out and community meetings will have to be attended.

Finally, the manufacturer can be contacted and the turbine can be ordered. In some cases up to a two year waiting period can be required before the turbines can be built. Construction itself will only take a matter of weeks or months.

APPENDIX E CONTENTS

APPENDIX E.1 SHORT TERM CONNECTION 123
APPENDIX E.2 DATA COMMUNICATION 125
APPENDIX E.3 LONG TERM CONNECTION 129
APPENDIX E.4 RESOURCES/CONTACTS 133

APPENDIX E.1 SHORT TERM CONNECTION

TABLE E-1: COPPER WIRE ANALYSIS

Inputs

			Eqn.
Turbine Power	1800	W	
Line Voltage	240	V	
Wire Type	Copper		2
Transmission Length	425	ft	
Tower Height	35	ft	

Design Assumptions

Trench Cost	$ 6.00	$/ft	
Max Voltage Drop	2%		

Calculated Variables

Line Current	*8*	*A*	1
Minimum CM	*18544*		2
Wire Gauge	*7*	*AWG*	3
Actual Wire Diameter	*0.1443*	*in*	4
CM	20818		5
Wire Cost	*$ 1.29*	*$/ft*	
Wire Resistance	*0.458*	*Ohms*	6

Outputs

Power Lost	25.8	W	
Voltage Drop	4.28	V	
Voltage Drop	1.78%		
Efficiency	98.6%		
Wire Type	7 AWG Copper		
Trench Cost	$ 2,550.00		
Wire Cost	$ 1,189.72	2 conductors	
CE Cost	$ 500.00		
Total Cost	$ 4,239.72		

TABLE E-2: ALUMINUM WIRE ANALYSIS

Inputs

			Eqn.
Turbine Power	1800	W	
Line Voltage	240	V	
Wire Type	Aluminum	1	
Transmission Length	425	ft	
Tower Height	35	ft	

Design Assumptions

Trench Cost	$ 6.00	$/ft
Max Voltage Drop	2%	

Calculated Variables

			Eqn.
Line Current	*8*	*A*	1
Minimum CM	*30475*		2
Wire Guage	*5*	*AWG*	3
Actual Wire Diameter	*0.1819*	*in*	4
CM	33102		5
Wire Cost	*$ 0.37*	*$/ft*	
Wire Resistance	*0.473*	*Ohms*	6

Outputs

Power Lost	26.6	W
Voltage Drop	4.42	V
Voltage Drop	1.84%	
Efficiency	98.5%	
Wire Type	5 AWG Aluminum	
Trench Cost	$ 2,550.00	
Wire Cost	$ 338.86	2 conductors
CE Cost	$ 500.00	
Total Cost	$ 3,388.86	

Wire Analysis Equations, Assumptions, and Sources

Equations

Equation 1	$I = P / V$
Equation 2	$CM_{\min} = \dfrac{2KIL}{eV}$
Equation 3	$AWG = Int\left[\dfrac{Ln\left(\dfrac{CM_{\min}}{105530.3}\right)}{-0.23188}\right]$
Equation 4	$D = 0.005 * 92^{\frac{36-AWG}{39}}$
Equation 5	CM=105530.3*e$^{-0.23188*AWG}$
Equation 6	$R = \rho L / A$ ρ = resistivity of the material composing the wire

K = K Factor from Table below
e = Voltage Drop (2%)
L = Wire Length

Costs:

*Wire costs from Southwire September 2006 cost charts
**THHN Wire Type Used (THHN is suitable for building services)

Wire Materials

Material	*Resistivity (10^{-8} ohm-m)*	*K Factor*
Aluminum	*2.828*	*21.2*
Copper	*1.724*	*12.9*

COMMERCIAL
Distributor Net Price Sheet

316C

Copper Building Wire

Date: September 25, 2006

Prices shown are per 1,000 feet. Subject to change without notice. This sheet supersedes Sheet #315C Dated September 6, 2006.

Size	THHN	USE	XHHW	TFFN	TFN
SOLID					
18 AWG	------	------	------	------	$176.53
16	------	------	------	------	238.91
14	$234.09	------	------	------	------
12	358.84	$686.24	------	------	------
10	563.57	998.47	------	------	------
STRANDED					
18 AWG	------	------	------	$176.53	------
16	------	------	------	238.91	------
14	$267.22	$578.60	$408.09	------	------
12 AWG	409.66	645.25	581.77	------	------
10	644.79	896.27	889.08	------	------
8	1,037.02	1,556.05	1,281.87	------	------
6	1,564.65	2,098.87	1,866.07	------	------
4 AWG	2,449.79	3,104.80	2,883.07	------	------
3	3,069.74	-----	3,533.77	------	------
2	3,855.27	4,652.14	4,480.03	------	------
1	4,876.15	6,187.41	5,668.07	------	------
1/0 AWG	5,529.07	7,094.02	6,242.86	------	------
2/0	6,908.72	8,690.74	7,810.92	------	------
3/0	8,659.04	11,176.67	9,693.86	------	------
4/0	10,853.32	14,026.44	12,142.63	------	------
250 kcmil	12,512.69	15,961.40	14,829.88	------	------
300	14,888.83	18,973.60	17,603.72	------	------
350	17,461.98	21,831.32	20,566.52	------	------
400	19,893.28	25,018.81	23,441.60	------	------
500 kcmil	24,665.41	30,976.29	29,202.51	------	------
600	29,625.93	35,499.90	35,115.03	------	------
750	43,036.28	53,204.84	52,250.99	------	------
1000	57,056.28	70,081.88	69,132.55	------	------

Cutting and Paralleling Charges Per Reel	Cutting Only 1 Conductor	Paralleling 2 Conductors
Sizes AWG 18-AWG 2	STD PKG ONLY	$35.00
Sizes 1- 500 kcmil	$22.00	65.00
Sizes 600 kcmil - 1000 kcmil	27.50	100.00

Cutting and Paralleling Charges Per Reel	Cutting Only 3 conductors	Paralleling 4 conductors
Sizes AWG 18-AWG 2	$50.00	$70.00
Sizes AWG 1 - 500 kcmil	95.00	125.00
Sizes 600 kcmil - 1000 kcmil	130.00	150.00

(Paralleling charge includes the cost for cutting. An additional charge of $20.00 will apply to any cuts less than 250 feet shipped on reels.)

Notes:

THHN, USE, XHHW, TFFN & TFN Products carry multiple ratings. Please see Southwire catalog for detailed information.

THHN, sizes 14 and 12, are packaged 4-500ft. spools (2000 ft.) in a case.

THHN, size 10, is packaged 2-500ft. spools (1000 ft.) in a case.

TFFN & TFN sizes 18 and 16, are packaged 4-500ft. spools (2000 ft.) in a case.

Orders for items packaged in cases must be in case multiples.

"Call Southwire for your industrial power cable and flexible cord products."

Southwire®

82AC

Distributor List Price Sheet

COMMERCIAL

Aluminum Building Wire

Date: August 2, 2006

Prices shown are per 1,000 feet. Subject to change without notice. Supersedes Sheet #81AC dated July 12, 2006.

Size		THHN*		XHHW		USE	
		WT./MFT.	PRICE	WT./MFT.	PRICE	WT./MFT.	PRICE
6	AWG	38	$333.74	42	$333.74	45	$406.37
4		61	414.15	58	414.15	64	466.90
2		90	562.00	85	562.00	93	648.47
1		116	820.52	109	820.52	124	900.94
1/0	AWG	140	984.80	133	984.80	149	1,109.31
2/0		171	1,163.77	163	1,163.77	180	1,302.12
3/0		209	1,444.78	200	1,444.78	219	1,532.10
4/0		256	1,609.05	246	1,609.05	267	1,704.14
250	kcmil	309	1,960.93	295	1,960.93	322	2,311.97
300		363	2,707.97	348	2,707.97	376	3,006.26
350		416	2,754.66	400	2,754.66	430	3,071.97
400	kcmil	469	3,223.27	452	3,223.27	484	3,749.83
500		575	3,551.86	555	3,551.86	591	4,124.21
600		697	4,499.46	678	4,499.46	----	----
700	kcmil	802	5,193.74	781	5,193.74	----	----
750		854	5,249.07	833	5,249.07	874	6,155.18
900		----	----	987	7,203.09	----	----
1000		1115	7,811.79	1090	7,811.79	----	----

*Aluminum THHN requires a minimum order of 20,000 ft. per size.

Cutting and Paralleling Charges Per Reel	Cutting Only 1 Cond.	Paralleling 2 Cond.
Sizes AWG 6 through AWG 1	$10.00	$30.00
Sizes AWG 1/0 through 500 kcmil	20.00	56.00
Sizes 600 kcmil through 1000 kcmil	25.00	90.00

Cutting and Paralleling Charges Per Reel	Paralleling 3 Cond.	Paralleling 4 Cond.
Sizes AWG 6 through AWG 1	$44.00	$58.00
Sizes AWG 1/0 through 500 kcmil	82.00	106.00
Sizes 600 kcmil through 1000 kcmil	115.00	134.00

(Paralleling charge includes the cost for cutting. An additional charge of $20.00 will apply to any cuts less than 250 feet shipped on reels.)

Notes:

1. THHN, XHHW & USE Products carry multiple ratings. Please see Southwire catalog for detailed information.
2. Aluminum Conductors are Southwire Alumaflex™ 8000 Series Aluminum Alloy.

Southwire®

APPENDIX E.2 DATA COMMUNICATION

DECISION PROCESS

Initial Design:

Cables through existing conduit

Conduit is collapsed in several places

Secondary Design:

SkyStream wireless communication device

Baseball shed and utility shed are both in range and have Ethernet capability per CIT meeting

Cost is relatively low ($300)

Easier to maintain/fix than an underground cable

Backup Design:

Purchase a separate metering device

More expensive

Performs same operation as SkyStream device

NOTES FROM MEETING WITH CIT

- The tunnels between Bunker and Gainey are crushed. There are 12 useable fiber optic cables and approximately 50 phone cables running in these tunnels.
- Set up of our own wireless access points would also run about $300.
- There is one Ethernet cable running to the Calvin ball diamond near Gainey.
- Using wireless as the single mode of transmitting the data would not concern them as far as reliability goes. (Presumed using our own quality, reliable wireless equipment, hopefully the Skystream system is as reliable)

APPENDIX E.3 LONG TERM CONNECTION

In order to connect a large scale turbine to the grid, there are several items to consider. Since the turbine will be producing a considerable amount of power, it would be recommended to connect to a primary, 12000 V power line. Calvin does not currently have a primary line that runs to the Gainey field location, so one would have to be installed. Due to Calvin's regulations, this line would need to be encased in concrete. The connection between the wind turbine generator and the grid is diagrammed in Figure E-1.

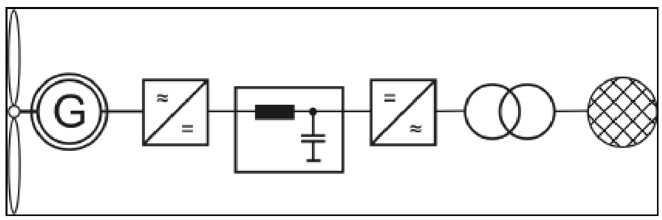


Figure E-1: Scheme of a modern gearless wind power system consisting of wind turbine, generator, rectifier, stabilizer, inverter and grid connection via a transformer.

The turbine produces DC power at around 480 V which needs to be conditioned by a rectifier and a stabilizer. The inverter converts the DC power to three phase AC power. Before connecting to the grid, the power needs to be stepped up to a higher voltage through a transformer. A switch gear also needs to be included to prevent power from entering the grid in the case that there is a power outage. The transmission wire that would be used between the turbine would be industrial quality 6/0 copper wire (or larger, depending on the eventual turbine selection), based on a 2 % voltage drop across the wire. A detailed diagram of the required parts as required by Consumer's Energy is shown in the attached diagram.

Costs for connecting the wind turbine to the grid were calculated by researching prices online. The main drivers for the costs were the transformer and the inverter, so the other electronic parts were neglected at this time. We were only concerned with general estimates at this time. We also found multiple reports that used a complete installation and start up costs of large scale turbines of $1000/kW. This price assumes a complete start up of a turbine, including parts and connection to the grid. A summary of the cost estimates are given below.

LONG TERM INFRASTRUCTURE COSTS

1. By Individual parts:

- Rectifier and stabilizer components will be negligible compared to the cost of the transformer and inverter.

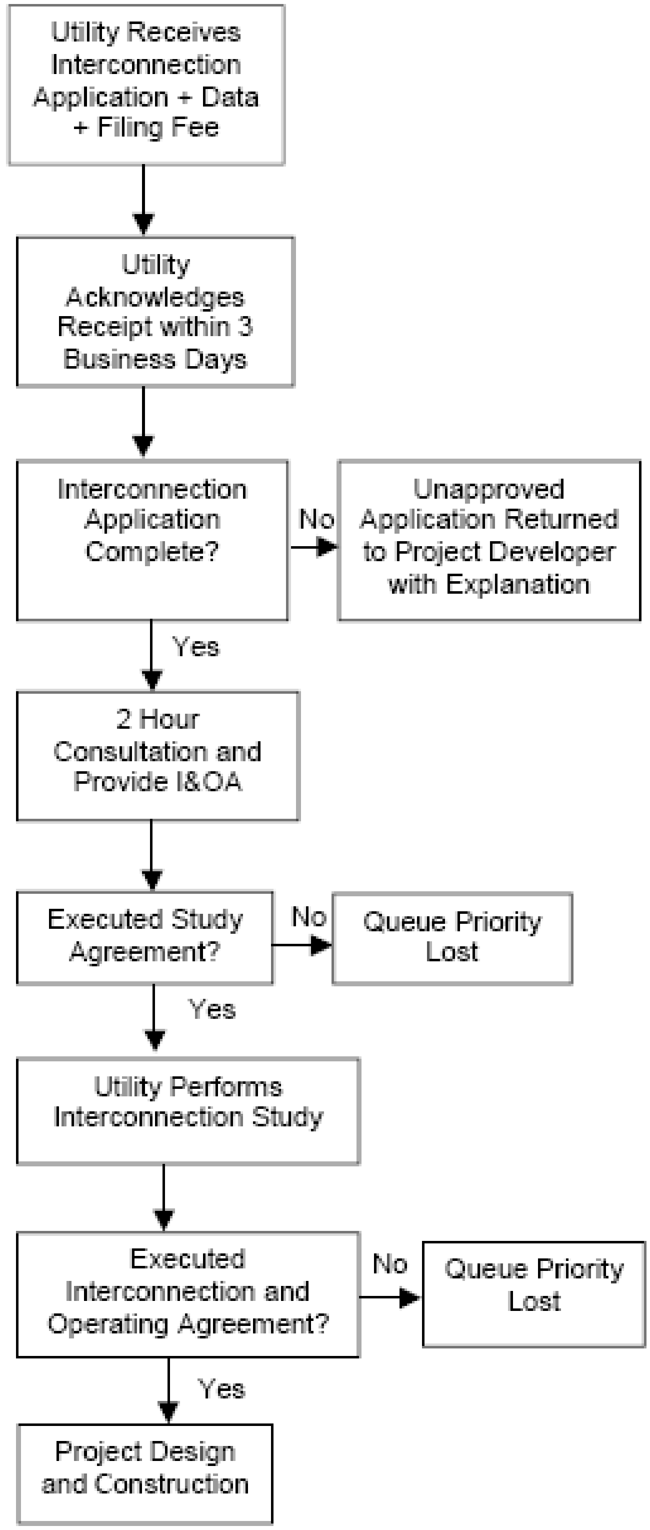
Turbine	500 kW	750 kW	1 MW
Transformer	$7,500.00	$8,784.90	$9,827.95
Inverter	$150,298.00	$279,377.97	$521,946.77
Total	$157,798.00	$288,162.88	$531,774.72

Sources:
http://www.swgr.com/products/DRYXHI_Inv_HEVI-DUTY_PG001.asp
http://www.advancedenergyonline.com/catalog/Inverters/3-Phase.htm

2. Entire Installation of a single turbine, based on $1000/kW:

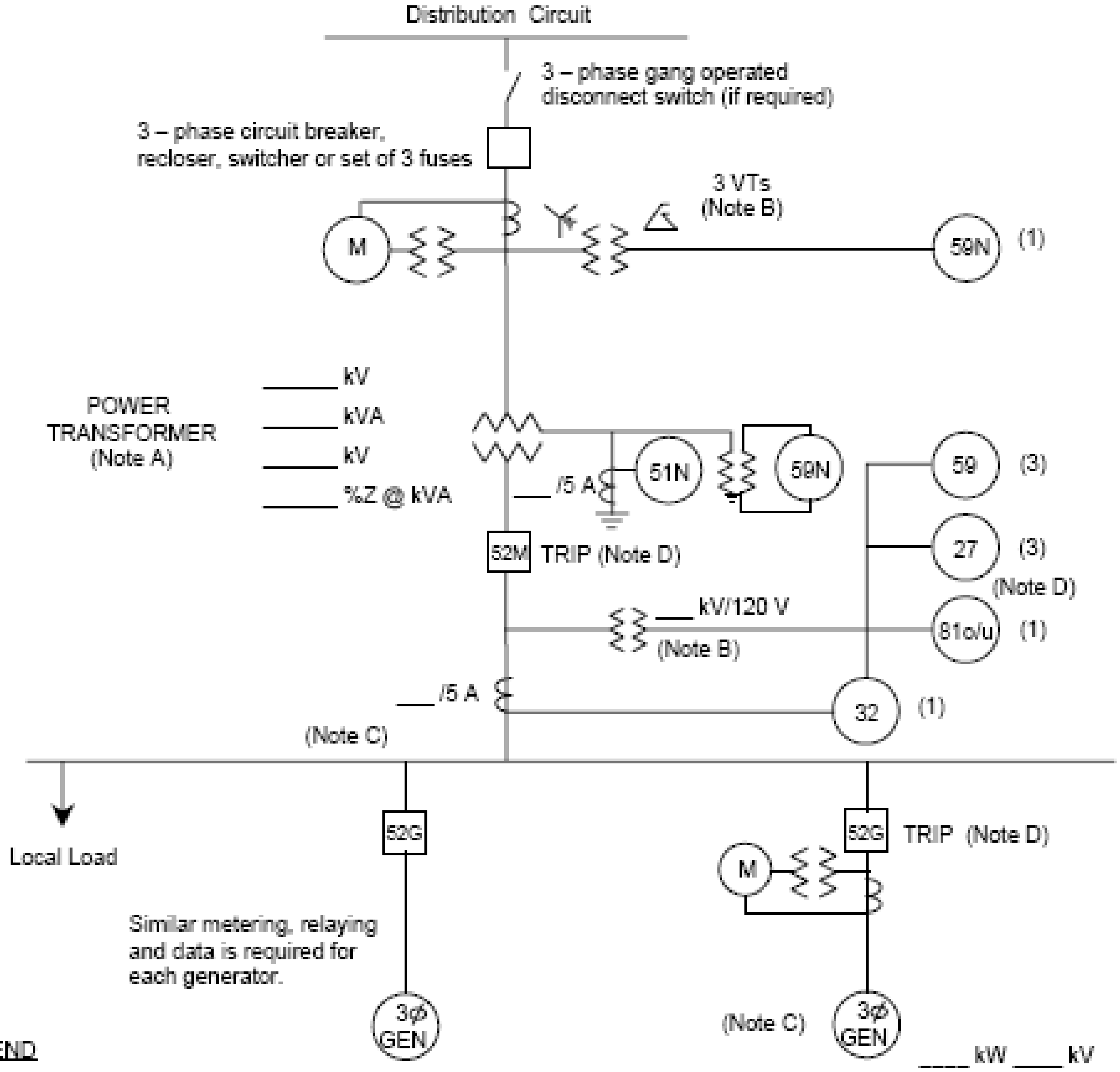
Turbine	500 kW	750 kW	1 MW
Total	$500,000.00	$750,000.00	$1,000,000.00

Sources:
http://www.awea.org/pubs/factsheets/EconomicsofWind-March2002.pdf#search=%22Large%20scale%20wind%20turbine%20economics%22
http://www.awea.org/faq/cost.html#WIND%20POWER%20COSTS%20DEPEND



Consumers Energy Interconnection Process

ONE-LINE REPRESENTATION
TYPICAL ISOLATION AND FAULT PROTECTION FOR INVERTER GENERATOR INSTALLATIONS
150 kW OR LARGER, BUT LESS THAN 750 kW



LEGEND

27	Undervoltage
32	Reverse Power (not required for sellback)
51N	Neutral overcurrent (required for grounded secondary)
59	Overvoltage
59N	Zero sequence overvoltage (assuming ungrounded secondary on power transformer)
81o/u	Over/Underfrequency

NOTES

A) See technical requirements for permissible connection configurations and protection. Transformer connections proposed shall be shown on the one-line diagram by the Project Developer. Transformer connection and secondary grounding to be approved by Utility.

B) Protection alternatives for the various acceptable transformer connections are shown. Only one protection alternative will ultimately be used, depending on the actual transformer winding connections. VTs for 59, 27, 81o/u and 32 are shown connected on the primary (Project side) of the power transformer, but may instead be connected on the secondary (Utility side). VTs are required on the secondary of the power transformer if a 59N is required for an ungrounded secondary connection. IEEE std 1547 requirements for voltage and frequency must be met at the PCC. IEEE Std. 1547 permits the VTs to be connected at the point of generator connection in certain cases.

C) Main breaker protection, generator protection and synchronizing equipment are not shown.

D) Trip of all 52G breakers or the 52M breaker is acceptable, depending upon whether the Project Developer wants to serve its own isolated load after loss of Utility service.

APPENDIX E.4 RESOURCES/CONTACTS

The main contact for our group was Chuck Holwerda from the electronics shop. Chuck's office is in the basement of the Science building and he can easily be contacted by email. He has done quite a bit of research into this topic in the past and is quite knowledgeable. He is an excellent source to discuss ideas with and will offer his advice. Chuck is also the one responsible for setting up the computer kiosk in the Bunker center. He will have to be contacted for specific details about the kiosk display.

Chuck took us on a tour of the Bunker Interpretive center which proved to be very useful. The solar panels on the roof are another form of alternative energy which Calvin is using. The connection between the solar panels and the bunker center is similar in many ways to the connection needed for the wind turbine.

We also contacted Lucas DeVries, the campus electrician. He can usually be found in the physical plant office, or can be contacted by email. If he is not in his office at the time he can be paged and he will be more than happy to offer his advice. We received a map of Calvin's electrical grid from him, along with advice about the campus' plans for future expansion. He also has contacts at the company which would be doing the conduit boring.

Paul Pennock took us on a tour of Calvin's Cogeneration plant and throughout the rest of Calvin's power generation systems. We made it up to the roof to examine the demonstration solar panel. Starting with a demonstration panel allowed the college to later invest in a full solar array for the Bunker Center. This is the same strategy that we are using with this wind turbine project.

APPENDIX F PROJECT HANDOUT

Calvin College both purchases and generates electricity for use on its Knollcrest campus. Electricity purchases are made from "the grid." Electricity is generated on-site by (a) converting natural gas into electricity using Calvin's Co-generation system, located in the basement of the Commons and (b) photovoltaic solar panels on the roof of the Ecosystem Preserver Interpretive Center.

There are many benefits to generating electricity on-site: providing options for lowest-cost electricity generation among multiple sources (reduced college operating costs and *lower tuition*), independence from traditional electricity sources for extreme events such as storms and power failures, and protection of critical infrastructure. There are also drawbacks, chiefly up-front capital investment in infrastructure and ongoing maintenance requirements.

Your challenge for this semester-long project is to construct a realistic plan to make a *significant impact* on the Calvin College campus with electrical power generated from wind resources. Doing so will continue to demonstrate Calvin's interest in alternative and renewable energy resources.

Elements of your proposed plan should include:

- Evidence of thorough research into technology options for achieving the stated objectives, including print and online resources and personal interviews and contacts
- A schedule showing a timeline for construction of facilities
- Proposals for locations of any new facilities required to meet the goal
- Detailed documents describing the design of the wind energy systems
- Detailed documentation showing that the proposed systems will meet the stated requirements
- A realistic plan to finance capital projects
- A financial evaluation of the economic advisability of your design plan.

Your deliverables are:

(a) a single final report from each section that proposes a feasible plan for make a significant impact on campus with wind energy,

(b) two posters to be presented at the Calvin Environmental Assessment Program (CEAP) conference on 30 November 2006, and

(c) a departmental seminar given by the classes (each section has 30 minutes) on 1 December 2006.

The customer for this design analysis project is Calvin's Vice-President for Finance, Henry DeVries.

The first phase of this plan is already underway. During the summer of 2006, Calvin College submitted a proposal to the Energy Office of the State of Michigan for funding to erect a small 1–3 kW demonstration turbine that would be integrated with the interpretive center's renewable energy emphasis. One task this semester is to define the site, height, hardware (turbine, tower, generator, inverters, instrumentation, etc.), schedule, assess and solve zoning issues, etc. for the demonstration project.

Beyond the small demonstration project, for which we will receive external (and some internal) funding, you must develop plans for making a significant impact on the campus using wind power. You must define financing options, assess turbine technology options, address site issues, determine how best to integrate with the campus infrastructure, define schedules, identify how later phases grow from the first phase, etc.

To develop the required plan, the class will be divided into several small teams of 5 students each. (One team will have 4 students.) Each group has initial roles and responsibilities defined, but you may find it necessary to adjust the management structure as the semester progresses. The following table provides details about the groups.

Team	**Initial Responsibilities**
Management	Coordinate team activities throughout the semester Define class priorities Define schedules for the plan Develop economic models Develop funding and financing plans
External Relations	Understand zoning regulations and issues Develop a communications strategy for interactions with • campus politics • neighbors • utility companies • etc.
Long-term Technology	Define hardware, siting, integration plan, etc. for anything beyond the demonstration turbine. Identify costs for various design options.
Short-term Technology	Define hardware, siting, integration plan, etc. for the demonstration turbine. Identify costs for the various design options.
Campus Infrastructure	Assess how “significant impact” can be made (grid segmentation, perhaps) Define control systems Define energy storage systems

The first tasks for each group will be to focus your area of inquiry for the project, in consultation with the other groups, and develop a schedule for your work this semester.

All groups must arrange a tour of Calvin’s existing physical plant facilities (including the co-gen plant) with Paul Pennock (see *Resources* below).

There will be three short, in-class progress reports in the form of oral presentations. There will be a longer in-class final presentation that summarizes the results of the Calvin design project. Each student must give either one of the progress report presentations or part of the final presentation. The presentations must be professional quality, must concisely report your progress, and provide sufficient technical detail for peer and professor review of your progress.

The in-class progress reports must include the following elements:

- Status relative to your schedule (and any re-planning that has occurred since your last report)
- Work accomplished since your last report (including technical details)
- Issues or concerns (and plan for addressing them)
- Work planned for upcoming reporting period

The final in-class oral report should provide the final technical details of your analysis, how your technical analysis was used in the final plan for your group, and the final conclusions for your group.

Bring printed copies of your presentations for guests and the professor.

The final written report should follow the technical memo format, including a two-page summary with conclusions. The management group is responsible for the introductory two pages. Each of the other groups should provide a detailed appendix (in technical memo format, of course) to the overall technical memo that describes the analysis performed and the proposals developed by the group.

Students will be graded on (a) the quality of their group's contribution to the overall effort of the class and (b) peer evaluation. The professor, in conjunction with our external resource persons, will select an exemplary student for a teamwork award.

As stated above, the audience for the final written report is the Calvin College Vice President for Finance, although the final grade will be assigned by the professor. Your final report will consist of

(a) a paper copy of a technical memo with extensive appendices and
(b) electronic copies of any programs or analysis tools that you developed during the project.

You must distribute copies of your final report to the VP for Finance, your resources (see below), and the professor. You must also send a note of appreciation to your resources for their assistance during the semester.

Resources:

- Paul Pennock, Calvin Physical Plant: contact for physical plant tours and general physical plant information
  (616) 262-9230 (mobile)
  pennockp@aol.com (email)
- Henry DeVries, VP for Finance, hdevries@calvin.edu, 6-6148
- Chuck Holwerda, Electronics Shop, 6-6438
- Classroom learning on exergy, economics, and thermal analysis
- Prior laboratory and lecture classes

Group selection will be conducted by the professor. To apply for one of the available positions, prepare a cover letter and resume and deliver it to the professor by **Monday 11 Sept 2006**. Your cover letter should indicate your interest in either a management, external relations, long-term technology, short-term technology, or infrastructure position.

Calvin ENGR 333 Wind Energy Project Schedule (2006)

CLASS MEETS MTWF 11:30–12:20 IN SB102

Day	Date	Activity
Wed	6 Sep	Project introduction, objectives, deliverables
Mon	11 Sep	Cover letter and resume due
Tue	12 Sep	Group assignments announced via KnightVision
		Project work

Tue 19 Sep In-class group presentations (7 minutes + 2 for questions)

Report on objectives, work schedule, and proposed analysis approach

Day	Date	Activity
Tue	26 Sep	Project work

Tue 3 Oct In-class group presentations (7 minutes + 2 for questions)

Report on analysis performed to date

Day	Date	Activity
Tue	10 Oct	Project work
Tue	17 Oct	Project work
Tue	24 Oct	Project work

Tue 31 Oct In-class group presentations (7 minutes + 2 for questions)

Report on preliminary results

Day	Date	Activity
Tue	7 Nov	Project work
Tue	14 Nov	Project work
Wed	15 Nov	Project work
Fri	17 Nov	Project work
Mon	20 Nov	Project work
Tue	21 Nov	**Project final presentations (13 minutes + 2 for questions)**
Wed	22 Nov	**Project final presentations (13 minutes + 2 for questions)**
		Report on final results
THUR	**30 NOV**	**CEAP POSTER SESSION**
Fri	**1 Dec**	**ENGR Department Seminar**
Fri	15 Dec	Final written report due at Noon